JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES

VOL. 45 JULY 1955 No. 7

PALEONTOLOGY.—*Reclassification of the Rotaliidea (Foraminifera) and two new Cretaceous forms resembling* Elphidium[1]. ALAN H. SMOUT, Iraq Petroleum Co., Ltd., London, England. (Communicated by Alfred R. Loeblich, Jr.)

(Received March 9, 1955)

The two species of Foraminifera to be described herein, *Elphidiella multiscissurata*, n. sp., and *Fissoelphidium operculiferum*, n. gen. and n. sp., are small, planispiral forms with shell material of radially arranged, perforate calcite. They show secondary thickening and have a canal system. They usually occur together in Maestrichtian marls that contain many well known index species, notably *Siderolites calcitrapoides* Lamarck, 1801, *Omphalocyclus macropora* Lamarck, 1816, and *Trechmanella persica* L. R. Cox, 1934. The accuracy of the age attribution can be taken as of a very high order. *E. multiscissurata* has a close resemblance to species referred to *Elphidiella* Cushman, 1936, but differs in having a carinate margin and slight grooves on the chamber walls, originating from the rows of pores on the radial sutures. *F. operculiferum* is an unusual species with a system of fissures and granules arranged very similarly to those on the ventral side of the test in *Rotalia trochidiformis* Lamarck, 1804.

The systematic position of these species presents a nomenclatorial problem that has been confused by the inclusion with the radial, canaliculate Foraminifera of others that have shell material of a different nature. The superfamily Rotaliidea has been shown (Smout, 1954) to have a type species, *Rotalia trochidiformis* Lamarck, 1804, in which the shell material is radial, perforate calcite (Wood, 1949), deposited in laminae that correspond each to a chamber, each covering the whole test. A canal system is present. The Foraminifera that have tests of this character form a compact group within which phylogeny is relatively easy to trace. In addition, there is no known case where intergradation with non-canaliculate genera occurs, with the exception of some highly complex derivatives of canaliculate species. There is a strong case for restricting the superfamily Rotaliidea to the laminated, radial, canaliculate genera. The otherwise similar but non-canaliculate genera (Discorbidea Smout, 1954) are the nearest group to the Rotaliidea, and are probably ancestral to them. They typically have an aperture while the Rotaliidea have no aperture or a few pores on the terminal face. The interiomarginal slit found in the septa of many Rotaliidea does not correspond to a former aperture. The remainder of the Foraminifera that are traditionally placed in the Rotaliidea are completely unrelated to them. These include the Spirillinidae, Nonionidae (excluding *Elphidium* etc.), and the genera *Archaediscus* Brady, 1873, and *Nummulostegina* Schubert, 1907. The trochoid, granulate, perforate group of Wood (1949), eg. *Gyroidina* d'Orbigny, 1826, must also be removed from the Rotaliidea. The more

[1] This work is published by permission of the chairman and directors of the Iraq Petroleum Co. and was carried out under the direction of Dr. F. R. S. Henson. My thanks are due to Dr. P. Bermudez, Dr. P. Brönnimann, and Dr. R. Bataller for gifts of comparative material and to G. F. Elliott for bibliographical assistance. The new species were first named, described, and figured by A. N. Dusenbury in an unpublished company report on which we collaborated, and use has been made of his observations. The type specimens are deposited in the British Museum (Natural History), South Kensington, London. Topotypes are deposited in the U. S. National Museum, Washington, D. C.

recent taxonomic work, by Glaessner (1945) Hofker (1951), Sigal in Piveteau (1952), Bermudez (1952), Loeblich and Tappan (1953), and others, shows a progressive tendency to sort out the canaliculate Foraminifera from the others, but the process has not been carried to its logical conclusion because there was no underlying theory. It is now possible to set up a classification with clear morphological definitions and reduce the points of ambiguity to those cases where the critical characters have not been recorded for a genus, or their determination cannot readily be undertaken. Practical difficulties do arise. In particular, the secondary thickening of fossil species may be overlooked, for it may be removed by solution, leaving only the primary chamber walls externally. Those whorls that are covered by later ones can be seen in thin sections to have been thickened. All the radial, perforate, spiral Foraminifera, other than the Lagenidea, may have to be reincorporated in the Rotaliidea, and may contain the ancestral species of the canaliculate families; but as no connection has yet been traced, the non-canaliculate families can be omitted at present.

One may proceed to a major classification of the foraminifera that build the test of radial, laminated calcite:

Superfamily Lagenidea: Noncanaliculate with a terminal or peripheral aperture.

Superfamily Discorbidea: Noncanaliculate with an interiomarginal aperture, areal aperture, or showing derivation from such a form.

Superfamily Rotaliidea: Canaliculate with no aperture, or pores on the apertural face, or pores elsewhere, sometimes with interiomarginal intercameral foramina, or showing derivation from such a form.

Superfamily Rotaliidea

The accompanying table of stratigraphical occurrences and probable phylogeny has been compiled with the characters of numerous species in mind, rather than the diagnostic generic characters. It is found that a number of phyletic groups can be recognised which have simple distinguishing characters, provided one is willing to redefine genera and families where necessary. The result is a classification that differs significantly from any proposed before but without any general appearance of unfamiliarity. Five families can be very readily distinguished, and are natural phyletic groupings. The Nummulitidae have a distinctive marginal cord, the Elphidiidae have retral processes to the chambers, the Miogypsinidae have orbitoidal habit with an eccentric nucleoconch, the Rupertiidae are initially trochoid and are attached and the Baculogypsinidae have solid spines or spherical growth. Apart from a few highly specialized forms that obviously evolved from a member of these families, there is no necessity to make exceptions to these simple definitions. The Rotaliidae for the most part form an equally distinct group, being trochoid and not attached. They are the parent forms of the Miogypsinidae and the Rupertiidae. The family Miscellaneidae is used for all the difficult cases, but these have a similarity between themselves which, although it does not yield to simple definition or appear to indicate a monophyletic group, is reassuring to the taxonomist. It includes numerous species that are almost bilaterally symmetrical and are not easy to separate from species of *Rotalia* (*Neorotalia*) that have the dorsal and ventral sides similarly ornamented. It is suspected that genera of the Miscellaneidae have been differentiated repeatedly from *Neorotalia*. The strictly symmetrical species of the Miscellaneidae are thought to be related to asymmetrical ones in several cases. The Miscellaneidae have strong radial canals in all genera excepting *Sulcoperculina*, which is a very unusual form and a misfit in any family.

Family Rotaliidae

The test is trochoid and the dorsal and ventral surfaces are differentiated; all external openings being ventral, except for perforations. The canal system is various, but all genera have radial canals or fissures or umbilical cavities and intraseptal and subsutural canals are common if not universal.

Rotalia (*Streblus*, *Turbinulina*, *Ammonia*, *Hammonium*)[2]
Neorotalia
Kathina
Lockhartia
Sakesaria (*Eorupertia*)
Dictyoconoides
Dictyokathina
Notorotalia ?

There is little to add to the discussion of this family given in a previous paper (Smout, 1954),

[2] Genera in parentheses are considered to be synonyms.

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except as regards *Neorotalia* Bermudez, 1952. Bermudez has separated a group of species including *R. mexicana* Nuttall, 1928, and *R. viennoti* Greig, 1935. *R. calcar* d'Orbigny, 1826, should be included. The practical distinction between *Rotalia* and *Neorotalia* is not easy, but it is of great theoretical importance because *Neorotalia* is probably the persistent primitive stock of the superfamily Rotaliidea, and has probably given rise to a number of genera of the Miscellaneidae, as well as to the initial forms of some if not all families. Its most important characteristic is a distinct asymmetry without strong differentiation of the dorsal and ventral sides. From the origin of *Miogypsinoides*, it is known that this genus can give rise to bilaterally symmetrical families. It is obviously closely related to many species of the Miscellaneidae, but no more closely than to *Rotalia* itself. The definitely trochoid Rotaliidae give rise only to the family Rupertiidae.

Occurrence.—Upper Cretaceous to Recent.

Family Rupertiidae

The test is primitively trochoid but may be arborescent or acervuline. It is attached by the apex.

Homotrema	*Carpenteria*
Sporadotrema	*Acervulina* ?
Miniacina	*Victoriella*
Rupertia	

Rupertia and *Homotrema* are often placed in different families, but they merely represent evolutionary stages of one lineage. *Sakesaria*, of the Rotaliidae is thought to have become attached by the apex in the early stages; becoming *Rupertia*. The latter genus shows two tendencies. The axis may branch, as in the arborescent genera, or the chambers may be irregularly added in later stages, leading to *Carpenteria* and probably to *Acervulina*. There is a possibility that *Gypsina* belongs here, rather than in the Baculogypsinidae.

Occurrence.—Eocene to Recent.

Family Miogypsinidae

The test has orbitoidal median chambers, eccentrically arranged around the nucleoconch, often with lateral chambers. The adult is bilaterally symmetrical but the nepionic stage is primitively like *Neorotalia*.

Miogypsina	*Miolepidocyclina*
Miogypsinoides	*Miogypsinopsis*

The position and character of this family are generally recognized. These genera form a lineage derived from *Neorotalia*.

Occurrence.—Upper Oligocene and Miocene.

Family Discocyclinidae

This family belongs to the radial, perforate group of Foraminifera but its origin is not known. There are no obvious canals and there is a probability that the Discocyclinidae are derived from the Discorbidea.

Occurrence.—Eocene.

Family Orbitoididae

This family as at present recognized as polyphyletic. None of the genera have an obvious canal system. Some genera are suspected of being derived from the Rotaliidae.

Occurrence.—Upper Cretaceous to Recent.

Family Elphidiidae

"Tests free, planispiral, trochoid or uncoiling; wall calcareous, hyaline, perforate radial in structure, with a canal system opening into a single or double row of pores along the sutures, and with retral processes projecting across the sutures; aperture consisting of a single slit or row of pores at the base of the apertural face, or scattered pores on the face."

Elphidium (*Polystomella*)	*Elphidioides*
Faujasina	*Ozawaia*
Cribroelphidium	*Polystomellina*

Loeblich and Tappan (1953) proposed the definition given above. There is practical difficulty in separating those species that really have retral processes from those that have lateral ornament that gives a similar appearance. The general resemblance between genera of the Miscellaneidae and the Elphidiidae can be very great (see Figs. 6 a, b and 10 a, b). By definition *Elphidiella* has no retral processes and therefore has been removed to the Miscellaneidae. *Notorotalia* Finlay, 1939, probably is without retral processes and is provisionally placed in the Rotaliidae. The Elphidiidae retain the canal system and variability of the symmetry which are shown by their ancestral family, although it is

unusual for one species to show such variability as do those of the Miscellaneidae. It is not proven that any genus has an interiomarginal aperture, although it is sometimes present as an intercameral foramen.

Occurrence.—Upper Eocene?, Oligocene to Recent.

Family BACULOGYPSINIDAE

The test is primitively planispiral or trochoid, but the dorsal and ventral surfaces are not differentiated. The canal system is diffuse and confused with the perforations. The margin is rounded or absent. Advanced genera may become globular. Large spines are often present and are formed by the thickening and not by marginal projections of the chambers.

Siderolites (*Tinoporus*)
Baculogypsina
Baculogypsinoides
Silvestriella)
Gypsina ?
Sphaerogypsina ?

The spinose genera show a close resemblance to each other that leaves little doubt that they should be associated in one family. The canal system is very diffuse and should not be considered the same as that of the Miscellaneidae. The origin of *Gypsina* Carter, 1877, and *Sphaerogypsina* Galloway, 1933, is obscure and it is not certain that they should be included here; perhaps they belong to the Homotremidae.

Occurrence.—Upper Cretaceous to Recent.

Family NUMMULITIDAE

The test is planispiral and bilaterally symmetrical. The canal system is fine and ramifying without vertical canals or fissures and the margin has a differentiated marginal cord containing ramifying canals.

Subfamily NUMMULITINAE[3]

Nummulites (*Camerina*)
Operculina
Operculinoides
Operculinella
Assilina
Ranikothalia
Paraspiroclypeus

Subfamily HETEROSTEGININAE

Heterostegina
Spiroclypeus
Cycloclypeus

[3] The inclusion of these genera is not intended to indicate an opinion on their validity. A number of names not in general use have been ignored.

There has been a very great measure of agreement about this family, but a failure to state categorically that it is the nature of the canal system, particularly that of the marginal cord, that is the distinctive character from the other Rotaliidea, particularly from the Miscellaneidae. The marginal cord of the Heterosteginidae is sometimes suppressed by the reduction of thickening that automatically occurs in cyclical genera.

Occurrence.—Upper Paleocene to Recent.

Family MISCELLANEIDAE

The test is planispiral or trochoid but not differentiated in structure into obviously dorsal and ventral sides. The canal system is strongly developed with subsutural and intraseptal canals and either vertical canals or a system of fissures. There is no differentiated marginal cord. There are no spines or retral processes. A few aberrant genera have a complex spire or have lateral chambers.

Laffitteina
Pellatispira
Biplanispira
Miscellanea
Arnaudiella
Siderina?
Daviesina
Sulcoperculina
Fissoelphidium
Elphidiella
'Siderolites' vidali and *'S.' heracleae*
Pellatispirella ?

The differences between some of these genera become very slight when the protean nature of the group is realized and the changes of canal system and tendency to asymmetry are no longer regarded as features on which to distingush families in this particular group of genera. Advanced forms such as *Biplanispira* Umbgrove, 1937, are included when they are isolated endforms and clearly derived from typical genera of the family. *Elphidiella* is traditionally classified with *Elphidium* Montfort, 1808, and is probably the ancestral genus to the Elphidiidae, but it lacks the retral processes that are the only real justification for recognizing the Elphidiidae as a family distinct from the Miscellaneidae. It is logical to include difficult primitive forms in the Miscellaneidae. *Sulcoperculina* has no canaliculate marginal cord but it has a highly differentiated margin, which is unusual in the Miscellaneidae.

The genera *Calcarina* d'Orbigny, 1826, and *Siderolites* Lamarck, 1801, have been used as familial types without a clear decision about their characters. *Calcarina* is variously stated to have

C. calcar d'Orbigny, 1826, and *Nautilus spengleri* Gmelin, 1756, as the type species. D'Orbigny based his generic description and model on *C. calcar*, but the species was neither described nor figured. No reference to any previous work was cited for this species and the model does not constitute a valid indication of a species according to the Rules of Zoological Nomenclature. *C. calcar* d'Orbigny, 1826, is therefore a nomen nudum and its subsequent validation cannot affect the designation of *N. splengleri* by Cushman (1915), for this was a valid species included in the original list of species of *Calcarina* by d'Orbigny. *C. calcar* is not congeneric with *N. spengleri* for the spines of the former are produced from the marginal regions of the chambers, whereas the spines of *N. spengleri* are formed by the thickening, and are of the same nature as pillars and pustules. *C. calcar* is either a *Rotalia* or belongs to a genus closely related to *Rotalia*. *N. spengleri* belongs to the genus *Siderolites* Lamarck, 1801. The resemblance between it and *S. calcitrapoides* Lamarck, 1801, the type species of *Siderolites*, is so close that arguments have been put up for their identity. A specific distinction can be maintained but there is no necessity for generic distinction and similar species are found at various Tertiary horizons to link the geological record of *Siderolites* from the Upper Cretaceous to the Holocene. The refusal to admit *Siderolites* as a long-ranging genus with Tertiary species has coincided with the attribution of the Cretaceous species *Siderolites vidali* Douvillé, 1907, and *S. heracleae* Arni, 1932, to it. They have no spines and no closer resemblance to *Siderolites* than to *Laffitteina* Marie, 1946, *Daviesina* Smout, 1954, or *Elphidiella* Cushman, 1936. They resemble *Daviesina* in the planispiral, very feebly trochoid habit but have definite vertical canals while *Daviesina* has a combination of canals and fissures. *Laffitteina* and *Elphidiella* have distinct canal patterns. A new generic name is required.[4] All this establishes clearly that *Calcarina* should not be used as the type of a family and that the Siderolitidae, if the name is to be used, must include *S. calcitrapoides* but not necessarily *S. vidali* or *S. heracleae*.

It has already been remarked that *Neorotalia* of the family *Rotaliidae* has a similarity to *Laffitteina* and *Daviesina* and forms a plexus of primitive species that is probably the origin of the more distinctive forms of both the Rotaliidae and the Miscellaneidae. The Miscellaneidae may represent derivatives of *Neorotalia* that tend to be planispiral rather than be a monophyletic group. The inclusion of *Neorotalia* in the Miscellaneidae would fit better with a phyletic picture, but the morphological distinction of *Neorotalia* from *Rotalia* is difficult and a family distinction between these genera is unthinkable at present.

The majority of the genera of the Miscellaneidae are bilaterally symmetrical and the inclusion of *Daviesina* and *Laffitteina* is therefore debatable. These genera are frankly intermediate between the Rotaliidae and the Miscellaneidae but the structure on the two sides of the test is essentially the same, as in the typical Miscellaneidae while the structure of the dorsal and ventral sides of the test in any species of the Rotaliidae is different as regards the development of canals and ornament as well as perforation and the alar prolongations of the chambers.

Occurrence.—Senonian to Recent.

Genus **Elphidiella** Cushman, 1936

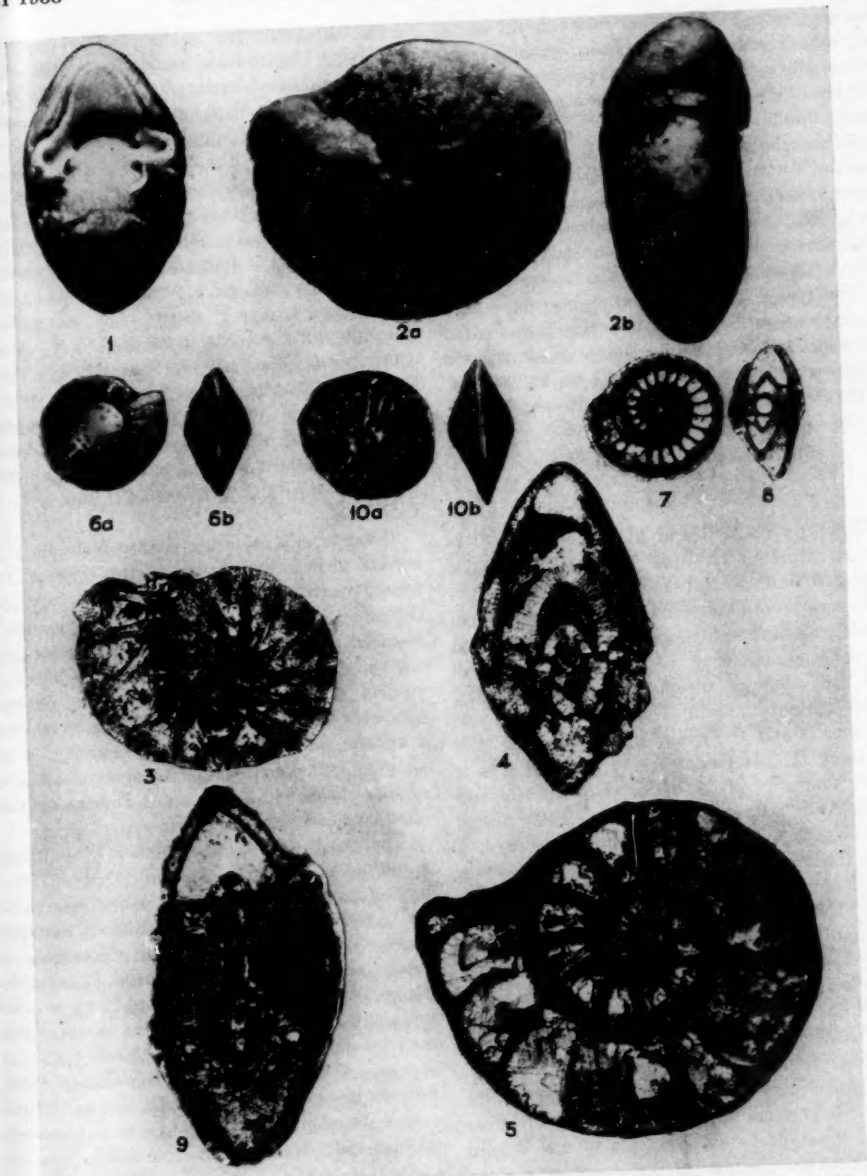
Type species, *Polystomella arctica* Parker and Jones, in Brady, 1864.

The test is bilaterally symmetrical and planispiral, with a simple spire of equitant chambers that usually leave an axial plug. There are subsutural and vertical canals that open along the radial and spiral sutures, usually forming a double row along each radial suture. The aperture consists of pores on the terminal face.

The species of this genus have no retral processes. Striate ornament that resembles them is sometimes present, caused by grooves that originate at the sutural pores and run on the chamber walls after the manner of trabeculae. In fossil specimens, it is sometimes very difficult to determine if retral processes are really present.

[4] **Pseudosiderolites**, n. gen. Type species, *Siderolites vidali* Douville, 1907. Test lenticular to biconical, bilaterally symmetrical; equitant chambers arranged in a plane spire. Shell material radially fibrous, laminated, perforate, composed of calcite. Radial canals numerous. Without spines, marginal canal or other marginal differentiation.

Other genera of the Miscellaneidae have the following distinctive characters: *Pellatispira* and *Biplanispira* are evolute; *Elphidiella*, *Laffitteina* and *Pellatispirella* have characteristic canal patterns; *Miscellanea* and *Fissoelphidium* have fissures, not radial canals; *Siderina* and *Daviesina* are obviously asymmetrical; *Siderolites* has spines; *Sulcoperculina* has a marginal sulcus and lacks radical canals; *Arnaudiella* has extra-spiral chambers.



FIGS. 1–5.—*Fissoelphidium operculiferum*, n. gen. and sp.: 1, Edge view, to show septum and broken chambers (B.M.N.H. P.42154); 2a, b, lateral and edge views of holotype (B.M.N.H. P.42155); 3, tangential section to show figures (B.M.N.H. P.42166); 4, axial section (B.M.N.H. P.42167); 5, equatorial section (B.M.N.H. P.42168). All ×30.

FIGS. 6–9.—*Elphidiella multiscissurata*, n. sp.: 6a, b, Lateral and edge views of holotype (B.M.N.H. P.42169) ×30; 7, equatorial section (B.M.N.H. P.42175) ×30; axial section (B.M.N.H. P.42176) ×30; 9, axial section (B.M.N.H. P.42177) ×100.

FIG. 10.—*Elphidium* cf. *E. crispum* Linné: Pliocene, Abu Shareb, Levant. 10a, b, Lateral and edge views for comparison with Figs. 6a, b (B.M.N.H. P.42178) ×30.

Some species that have been described as *Elphidium* lack retral processes; even in some cases when the latter have been recorded as present there is a doubt of the accuracy of the observations.

Elphidiella is already known to occur throughout the Tertiary. Brotzen records *E. prima* (Ten Dem, 1944) from the Paleocene. *Nummulites mengandi* Astre, 1924, is possibly an *Elphidiella*, but the typical canal system has not been demonstrated in this Upper Cretaceous species.

The typical unornamented species have little resemblance to *Laffitteina*, but there is no further difference between the two genera other than the symmetry of the test, itself not a marked feature.

Occurrence.—Maestrichtian to Recent.

Elphidiella multiscissurata, n. sp.

Figs. 6–9

Holotype P.42169 and paratypes P.42170–7, British Museum (Natural History), and topotype P.2026, U. S. National Museum.

Description.—The test is composed of hyaline, radially fibrous, perforate calcite and is laminated in the usual manner of the Rotaliidea. It is small and lenticular to biconical with a subacute, feebly carinate margin. The spire is simple and planispiral and the chambers are involute and equitant. The umbonal region on each side is about one third of the diameter of the test and occupied by a boss that is usually slightly raised. The chambers of the last half whorl are separated from the boss by a groove, which is continued as a spiral of about one and a half turns of pores. Only the last whorl of chambers is visible externally. The sutures are radial and slightly curved, limbate mostly but incised for the last few chambers. Each suture has a row of about 10 pores on each side of the test. They incline alternately forward and backward over the chambers, with tributary grooves that are inconspicuous over the latest chambers, but become more obvious on the older, thickened chamber walls. The alternate inclination of the sutural canals makes the row of pores appear double. There are no retral processes, nor any rudiments of them, but this can only be seen clearly on the last two or three chambers, which are often not preserved. The aperture is cribrate, being a row of about 10 pores in the interiomarginal position. No intercameral foramina have been observed with certainty. The proloculum is small and spherical. Dimorphism has not been observed.

Dimensions.—Diameter, 0.9 to 0.5 mm; thickness, 0.5 to 0.2 mm; diameter of nucleoconch, about 0.01 mm.

There are about three whorls with 20 to 25 chambers in the last whorl.

Distribution.—It has been found in Maestrichtian marls in deep boreholes on Jebel Dukhan, Qatar, Arabia, associated with *Siderolites calcitrapoides* Lamarck, 1801, *Omphalocyclus macropora* (Lamarck, 1816), *Loftusia morgani* Douvillé, 1904, *Lepidorbitoides socialis* (Leymerie, 1851). *Orbitoides apiculata* Schlumberger, 1902, and *Fissoelphidium operculiferum* gen. et sp. nov. It is also found at Aqra, N. E. Iraq in Maestrichtian limestones with the same associated species and in addition *Loftusia persica* Brady, 1869, *Cyclolites* spp. and *Trechmanella persica* L. R. Cox, 1934.

Remarks.—There is a difficulty in deciding the correct generic attribution of this species. The formal resemblance to *Elphidiella* is very considerable, but the latter genus typically has a rounded margin, whereas *E. multiscissurata* has a marked differentiation of the marginal region. A similar difference appears to occur between species of *Elphidium*, and it need not be taken as a generic character. The slight grooving on the chamber walls of *E. multiscissurata* is not typical of *Elphidiella*, but again is not a character that need be considered as generic.

The very striking resemblance of *E. multiscissurata* to *Elphidium crispum* (Linné, 1758) is more apparent than real because this species has no retral processes. *'Nummulites' mengaudi* Astre, 1924, from the Upper Cretaceous of Aquitaine is possibly an *Elphidiella*. It resembles *E. multiscissurata* very closely but has a rounded margin without a carina and the canal system may be different. In any case they are distinct species. *Elphidiella prima* (Ten Dam, 1944), fide Brotzen, 1948, from the Danian and Paleocene of Sweden and Holland also lacks a carinate margin and cannot be the same species.

Fissoelphidium, n. gen.

Type species, *Fissoelphidium operculiferum*, n.sp.

Description.—The test is planispiral and bilaterally symmetrical with a single spire of equitant chambers. The shell material is radially

fibrous, perforate calcite, deposited in laminae that correspond to the chambers and build up a spiral lamina and polar plugs as in *Nummulites*. The septa are double and there is a lateral system of wide meandrine fissures. The septa are double in appearance in thin section, particularly in tangential sections, for the fissures penetrate slightly into them. The margin is rounded and without a marginal cord.

Remarks.—This monotypic genus has a system of fissures resembling that of the ventral surface of *Rotalia*, but in *Fissoelphidium* they are found on both sides of the test. The dendritic fissures along the sutures recall the patterns formed by the canals in *Laffitteina*. The general appearance is suggestive of the Elphiidae, but there are no retral processes and there is no close resemblance to any species of *Elphidium*.

Occurrence.—Maestrichtian.

Fissoelphidium operculiferum, n.sp.

Figs. 1–5

Holotype P.42155 and paratypes P.42154, 42156–69, British Museum (Natural History), and topotypes P.2027, U. S. National Museum.

Description.—The shell material is hyaline, radially fibrous, perforate calcite, deposited in laminae that correspond each to a chamber, and thus form a spiral lamina and supplemental thickening in the same manner as in *Nummulites*. The slightly curved septa appear double in section and there is a canal system. The test is stoutly lenticular with a rounded margin and no trace of a marginal cord or carina. The chambers are arranged in a simple, plain spire. They are equitant with nearly straight, radial, alar prolongations that do not reach the poles. The radial sutures are incised. On the latest chambers they are straight, but small alternating branches of them increase in strength on the older parts of the test. Toward the periphery they render the suture line zig-zag, while nearer the poles they form anastomoses and cut the supplementary skeleton into incised granules. These grade imperceptibly into the incised granules of the umbonal regions. The initial branches of the septal sutures tend to be directed forward, producing a pattern that has a similarity to that of *Laffitteina*. The lowest parts of the fissures seem to be cut off to form a canal system of lateral spiral canals and tributary canals, all these running in the sutures. At the periphery the tributary canals become narrower and open into the fissures, and the spiral canals open into the fissures near the terminal chamber. The canals lie deep, but still in the peripheral part of the septum, and the sutural fissures penetrate a short way into the septa. There is no evidence of canals in the more central part of the septa. The perforations are coarse and evenly distributed. The proloculum is small and no dimorphism has been observed. The aperture consists of pores round an apertural plate that bulges outward. This is removed when the next chamber is formed, leaving an interiomarginal intercameral slit in the septum.

Dimensions.—Diameter, 2.2 to 1.3 mm; thickness, 1.0 to 0.5 mm; diameter of proloculum, 0.08 to 0.04 mm.

There are about three whorls with 12 to 15 chambers in the last whorl.

Distribution.—Type locality: Maestrichtian of Dukham Oilfield, Qatar Peninsula of Arabia, with *Elphidiella multiscissurata* and the fauna listed as accompanying that species.

Other localities: Maestrichtian of N. Iraq at Aqra, with *E. multiscissurata* and the same associated fauna and at Jebel Gara; in S. Iraq in the Maestrichtian of the Zubair Oilfield, near Basra; at Ras Sharwain, Qishn, (Mahra, Persian Gulf) where it is also of Maestrichtian age.

The system of deep fissures is probably a primitive character. As in *Miscellanea* and *Kathina* grooves and fissures are the equivalent of the canal system of more advanced genera. This aberrant species shows little similarity to any other but is probably closely related phyletically to the other Cretaceous Miscellaneidae. *'Nummulites' mengaudi* Astre has a similar appearance in photographs of thin sections. This is odd because neither fissures nor canals are mentioned in the type description. These two species might prove to be congeneric on further investigation, but they are unlikely to be identical. The dimensions of *F. operculiferum* are considerably greater than those of *'N.' mengaudii*.

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BOTANY.—*New Korean grasses and new names of grasses to be validated before publication of a manual of the grasses of Korea.* IN-CHO CHUNG, Botanical Gardens, University of Michigan. (Communicated by H. H. Bartlett.)

(Received February 3, 1955)

The writer has prepared a *Manual of the grasses of Korea* which, before publication as a book, will be microfilmed, since it has been presented as a dissertation at the University of Michigan. Since publication by microfilm is not recognized as valid by the International Rules of Botanical Nomenclature, it is necessary to extract for prior journal publication the new Korean taxa which are proposed, as well as certain names in new combinations required for uniformity of treatment in the *Manual*.

The purpose of the *Manual* is to give full descriptions, with clear-cut keys to all categories, of all known grasses of Korea, both South and North. The only grasses excluded

from the work are cultivated bamboos. The treatment is based as largely as possible upon material actually collected in Korea, which is available in the United States National Herbarium at the Smithsonian Institution, the Gray Herbarium of Harvard University, the University Herbarium of the University of Michigan, and the Herbarium of the New York Botanical Garden.

If material from Korea or closely adjacent regions was not available, the descriptions were either translated from the original ones, or, if those were too old and inadequate, from the best and most dependable monographs, or floras of the type regions.

So far as now known there are two hundred species of grasses in eighty-five genera in Korea, excluding cultivated bamboos.

One Siberian species, *Poa sibirica* Roshevitz, is new to Korea, and one Korean species, *Stipa pubicalyx* Ohwi, has been found to extend to the Soviet Far East, and so far as can be ascertained, is new to that country.

Three species, three varieties, and five forms are newly proposed; seven varieties and three forms have required framing new combinations in order to bring their names into conformity with the general treatment.

The descriptions of the new taxa follow:

Poa hamhungensis Chung, sp. nov.

P. viridulae similis sed differt culmis longioribus, lemmatibus obscure 5-nerviis, et palea lemma aequante.

Culmi pauci in caespite singulo, ascendentes, 55–65 cm alti, graciles, subteretes, 3-nodii, nodo ultimo infra culmi mediam, striati, scaberuli; vaginis superioribus quam internodiis brevioribus, scaberulis; laminis linearibus, acuminatis, plerumque brevioribus quam vaginis, 8–10 cm longis, 1.5–2 mm latis, scaberulis, ligulis 1–2 mm longis, obtusis, dorso scaberulis. Panicula angusta, 9–11 cm longa, ramis 2–4 ad nodum singulum; rachi et ramis scabris; ramis inferioribus 1.5–3 cm longis, in parte tertia inferiore nudis; spiculis viridibus 4.5–5 mm longis, 3- –4-floris; glumis lanceolatis, chartaceo-membranaceis, margine scariosis, 3-nerviis, scaberulis, prima acuminata, 2–2.5 mm longa, secunda acuta, 2.4–2.8 mm longa; lemmatibus 2.7–3 mm longis, acutis vel acutiusculis, apicem versus flavis purpureisque, obscure 5-nerviis, sursum scaberulis, villosis deorsum in parte carinae dimidia et in tertia parte vernarum marginalium, glabris in vena intermedia et inter venas, basi arachnoideo-lanosis; palea lemma aequante, ciliolata in carinis ambabus; staminibus 3; antheris 1 mm longis, flavidis; rhachilla glabra, minute scaberula. Specimen typicum legit T. Suzuki sub num. 8, anno 1941, ad locum Hamhung ("Kanko" dictum), in Hamkyong-Namdo, in U. S. Nat. Herb. conservatum sub num. 1,964,757.

Similar to *P. viridula* but differs from it in the taller culms, the faintly 5-nerved lemmas, and the palea equaling the lemma.

Culms few in a tuft, ascending, 55 to 65 cm tall, slender, nearly terete, 3-noded with the uppermost node below the middle of the culm, striate, scaberulous; upper sheaths shorter than the internodes, scaberulous; leaf-blades linear, acuminate, mostly a little shorter than the sheath, 8 to 10 cm long, 1.5 to 2 mm wide, scaberulous, ligules 1 to 2 mm long, obtuse, scaberulous on the back. Panicle narrow, 9 to 11 cm long, with 2 to 4 branches at each node; axis and branches scabrous; the lower branches 1.5 to 3.5 cm long, naked on the lower third; spikelets green, 4.5 to 5 mm long, 3- or 4-flowered; glumes lanceolate, chartaceous-membranaceous with scarious margins, 3-nerved, scaberulous, the first acuminate and 2 to 2.5 mm long, the second acute and 2.4 to 2.8 mm long; lemmas 2.7 to 3 mm long, acute or acutish, yellowish and purplish near the tip, faintly 5-nerved, scaberulous above, villous on the lower half of the keel and on the lower third of the marginal veins, glabrous on the intermediate vein and between the veins, wavy-haired at base; paleas equal to the lemma, ciliolate on the 2 keels; stamens 3; anthers 1 mm long, yellowish; rachilla glabrous, minutely scaberulous.

Type specimen: *T. Suzuki 8* (US 1,964,757) collected in 1941 at Hamhung, Hamkyong-Namdo.

Poa kyongsongensis Chung, sp. nov.

Poae matsumurae similis sed differt spicula majori 5- –8-flora, vagina longiore quam internodio.

Culmis ca. 57 cm longis, compressiusculis, basi 2 mm crassis, 2-nodosis, nodo superiore infra culmi mediam, infra nodos et infra inflorescentiam scaberulis; vaginis quam internodiis longioribus, compressiusculis, striatis; laminis planis, linearibus, acutis, 10.5–13 cm longis,

2–2.2 mm latis, glabris, scaberulis, infima basi purpurascenti; ligula membranacea, 2–3 mm longa, obtusa, in dorso scaberula; panicula laxa, ca. 18.5 cm longa, rhachi ramisque scabris, ramis ascendentibus, infra mediam nudis, inferioribus quinis fasculatis, fasciculis ex ramis 2 brevibus, 2 intermediis et 1 longissimo (9.7 cm longo) constantibus; spiculis viridibus, 5.5–7.5 mm longis, 5- –8-floris; glumis lanceolatis, acutis, chartaceis, margine scariosis, 3-nerviis, in costa scaberulis, prima 2.8–3 mm longa, secunda 3–3.5 mm. longa; lemmatibus 3.3–3.5 mm longis, 5-nerviis, obtusis, chartaceis, margine scariosis, apice flavescentibus purpurascentibusque, secus margines purpurascentibus, punctatim scaberulis, glabris in vena intermedia et inter venas, pubescentibus deorsum in parte carinae dimidia et in tertia parte venarum marginalium, basi arachnoideis; palea paulum breviore quam lemmate, ciliolata in costis; antheris (immaturis) 1–1.3 mm longis; rachilla glabra, minute scaberula.—Specimen typicum legit Ohwi prope Kyongsong in provincia Hamkyong-Pukto, Korea, 881 *pro parte* (!) in U. S. Nat. Herb. conservatum sub num. 1964478. Partes inferiores desunt. Specimen alterum est *Poa sphondylodes*.

Similar to *Poa matsumurae* but differs from it in the longer, 5- to 8-flowered spikelet and the sheath which is longer than the internode.

Culm 57 cm long, slightly compressed, 2 mm wide at base, 2-noded with the uppermost node below the middle of the culm, scaberulous below the inflorescence and nodes; sheaths longer than the internodes, slightly compressed, striate, scaberulous; leaf-blades flat, linear, acute, 10.5 to 13 cm long, 2 to 2.2 mm wide, glabrous, scaberulous, the lowermost purplish at base; ligules membranaceous, 2 to 3 mm long, obtuse, scaberulous on the back. Panicle open, 18.5 cm long; axis and branches scabrous; branches ascending, naked below the middle, the lowermost ones in a fascicle of 5 (2 shortest, 2 intermediate, the other longest and 9.7 cm long). Spikelets green, 5.5 to 7.5 mm long, 5- to 8-flowered; glumes lanceolate, acute, chartaceous, with scarious margins, 3-nerved, scaberulous on the keel, the first 2.8 to 3 mm long, the second 3 to 3.5 mm long; lemmas 3.3 to 3.5 mm long, 5-nerved, obtuse, chartaceous, with scarious margins, yellowish and purplish near the tip, purplish near the margins, punctate-scaberulous, glabrous on the intermediate nerve and between the veins, pubescent on the lower half of the keel and on the lower third of the marginal veins, wavy-haired at base; paleas a little shorter than the lemma, ciliolate on the 2 keels; anthers (immature) 1 to 1.3 mm long; rachilla glabrous, minutely scaberulous.

Type specimen: *Ohwi 881* (US 1,964,478) *P.P.*, collected at Kyongsong, Hamkyong-Pukto. This, without the basal part, is one of the two plants found on US 1,964,478 collected by Ohwi on June 2, 1930, at Kyongsong, the other being *Poa sphondylodes*. *Poa penicellata* Kom. in Kamchatka may be remotely related to *Poa matsumurae* and *Poa kyongsongensis*.

Poa ullungdoensis Chung, sp. nov.

Poae nemorali affinis, sed differt panicula angustiore ramis appressioribus foliisque plerumque involutis. A *P. kumgansani* differt culmis compressis, 5- –8-nodiis et spiculis parvioribus, glumis brevioribus.

Perennis; culmis caespitosis, 25–40 cm altis, gracilibus, simplicibus, basi geniculatis, 5- –8-nodis; vaginis haud apertis, saepe quam internodiis longioribus, eis inferioribus purpurascentibus, ut culmis compressis, striatis, glabris, laevibus; laminis anguste linearibus, 9–17 cm longis, saepissime involutis, 1–2 mm latis si applanatis, glabris, margine scaberulis; ligulis truncatis, 0.2 mm longis. Panicula 5–10 cm longa, 1–1.7 cm lata, ramis 2–5 ad nodos inferiores, appressis, haud verticillatis sed fasciculatis; ramis plus minusve scaberulis, vel simplicibus vel circa mediam partem ramosis, prope apicem pauci-spiculiferis, infimis 2.2–4.8 cm longis. Spiculae 2.8–5 (raro 7) mm longae, 2- –6-floriferae, plerumque 4-floriferae; glumis subaequalibus vel vix inaequalibus, prima 1.2–2.2 mm longa, 1-costata, secunda 1.7–2.8 mm. longa, 3-costata; carinis scaberulis vel laevibus; lemmate obscure vel conspicue 5-nervio, basi pilis undulatis praedito, subtus in costa pubescenti etiamque prope basem venarum marginalium, sed sursum et inter venus glabro; palea lemmate subaequali, 2-costata, costis scaberulis, apice indistincte 2-dentata vel integra; staminibus 3; antheris 1.2–2 mm longis, luteolis; lodiculis 2, membranaceis, cuneatis, emarginatis, 0.2–0.3 mm longis. Specimen typicum legit Chung (no. 1673) ex insula Ullung Do, 1 Jul. 1948; Oh 2479 etiam ex Ullung Do (ambobus in herb. Univ. Michiganensis conservatis).

Close to *P. nemoralis* but differs from it in the narrow panicle with appressed branches and the

usually involute leaves. Also distinguished from *P. kumgansani* by the compressed 5- to 8-noded clums and the smaller spikelets with shorter glumes.

Perennial; culms tufted, 25 to 40 cm tall, slender, simple, bent at base, 5- to 8-noded; sheaths closed, usually longer than the internodes, the lowermost ones purplish; culms and sheaths compressed, striate, glabrous, smooth; blades very narrowly linear, 9 to 17 cm long, usually involute, 1 to 2 mm wide when spread, glabrous, scaberulous on the margins; ligules truncate, 0.2 mm long. Panicle 5 to 10 cm long, 1 to 1.7 cm wide, with 2 to 5 appressed branches (not whorled) at lower nodes; branches more or less scaberulous, simple or branched near or above the middle, bearing a few spikelets at the ends, the lowermost branches 2.2 to 4.8 cm long. Spikelets 2.8 to 5 rarely 7 mm long, 2- to 4-, rarely 6-flowered; glumes slightly unequal to subequal, the first 1.2 to 2.2 mm long and 1-nerved, the second 1.7 to 2.8 mm long and 3-nerved, keels scaberulous or smooth; lemma faintly or conspicuously 5-nerved, wavy-haired at base, pubescent on the keel below and near the base of the marginal veins, glabrous elsewhere; palea subequal to the lemma, 2-keeled, scaberulous on the keels, slightly 2-toothed or entire at apex; stamens 3; anthers 1.2 to 2 mm long, yellowish; lodicules 2, membranaceous, cuneate, emarginate, 0.2 to 0.3 mm long.

Type specimen: *Chung 1673* (MICH) collected on 1 July 1948 in Ullung Do. Other Korean specimen examined: Ullung Do (*Oh 2479* MICH).

Agropyron yezoense Honda var. **glaucispiculum** Chung, var. nov.

A forma typica differt praecipue spiculis glaucis 7--9-floris glumis 3--5-nervis.—Specimen typicum et unicum legis Nakashima 25 Jun. 1942 prope Seoul, et conservatum in U. S. Nat. Herb. sub numero 1,964,760.

This differs from the typical form mainly in the glaucous 7- to 9-flowered spikelets and 3- to 5-nerved glumes.

Culms glaucous especially near the nodes; sheaths sometimes glaucous; blades linear, acuminate, 15 to 21 cm long, 4 to 6 mm wide, scaberulous, rarely pilose; ligules 0.5 to 0.8 mm long, truncate, brownish, membranaceous; spikelets 20 to 22 mm long, 7- to 9-flowered, glaucous; glumes 7.5 to 9 mm long, 3- to 5-nerved; lemma 9 to 11 mm long, 5-nerved, punctate on the back, hispid or hispidulous near the margins and more or less on the veins, glaucous; with a terminal scabrous awn 20 to 25 mm long; palea a little shorter than the lemma or equal, obtuse at apex, serrate-scabrous on the 2 keels, punctate and glaucous on the back; lodicules 2, membranaceous, 1 mm long; pilose beak of the caryopsis about 0.5 mm long; the hairs 1 mm long; rachilla scaberulous, 1.2 to 1.5 mm long, glaucous; callus 0.5 to 0.7 mm long; rachis scabrous on the edges, glaucous.

Type specimen: Nakashima June 25, 1942 (US 1,964,760), Seoul.

Eulalia speciosa (Debeaux) Kuntze var. **glauca** Chung, var. nov.

A forma typica differt vaginis inferioribus etiamque nodis culmorum glaucis, lodiculis ciliolatis, et antheris longioribus. A *Eulalia quadrinervi* distincta gluma prima pilosa et eaedem venis marginalibus supra mediam extinctis, lemmate fertile longiore et laminis foliorum longioribus.—Specimen typicum in Herbario Grayano conservatum legit R. K. Smith s. n. 20 Sept. 1934, prope "Sorai Beach" in Provincia Whanghaedo.

This differs from the typical form of *Eulalia speciosa* in the glaucous lower sheaths and nodes of the culm, the ciliolate lodicules, and the longer anthers. It is distinguished from *Eulalia quadrinervis* by the densely pilose first glume, the two marginal nerves of which disappear above the middle, the longer fertile lemma, and the longer leaf-blade.

Culms 115 cm tall, erect, unbranched, pubescent below the inflorescence, glaucous at nodes; sheaths open, longer or shorter than the internodes, lower sheaths glaucous; leaf-blades linear, acuminate, 30 to 40 cm long, about 6 mm wide, scabrous on margins, pruinose-glaucous above, pilose behind the ligules; ligules thickish, 0.7 to 1 mm long, truncate. Panicle 15 cm long, with subdigitate racemes; rachis obliquely jointed, compressed, densely whitish-pilose chiefly on edges and nodes; rachis-segments 4 to 4.5 mm long; spikelets 5 to 5.5 mm long, pilose; pedicels 3 to 3.2 mm long, sulcate, densely pilose on edges; glumes equal, broad-lanceolate, narrowly inflexed on margins; first glume subcoriaceous, 4-nerved, with the 2 marginal nerves disappearing above the middle, densely pilose on the usually slightly depressed back and on sides, hispidulous on edges near the tip; second glume chartaceous, 3-nerved, pilose on the rounded back, ciliate above the middle, puberulent on both surfaces near the tip; sterile lemma as long as the glumes,

lanceolate, chartaceous-membranaceous below, membranaceous and ciliate above, 2-nerved; fertile lemma 3.5 to 4 mm long, very narrow, membranaceous, puberulent above, slightly constricted on the back at the lower fourth, awned from between the teeth of the bifid apex; the awn 16 to 17 mm long, bent, twisted, puberulent; palea 1.5 to 2 mm long, narrowly linear, membranaceous, ciliolate at apex, thick, 0.6 to 0.7 mm long; callus very short; hairs of callus 0.8 to 1.5 mm long; stamens 3; anthers 3 to 3.2 mm long, brown; stigmas 2 to 2.5 mm long, plumose, dark-purple; style long.

Type specimen: *Smith* 9–20–1934, Sorai Beach in Whanghai-Do, GH.

Setaria lutescens (Weigel) Hubb. var. **dura** Chung, var. nov.

A forma typica differt lemmate flosculi inferioris convexo, chartaceo vel cartilagineo, transverse rugoso.—Specimen typicum et unicum legit Oh sub. no. 8090 in insula Sohuksan Do, conservatum in Herb. Univ. Michiganensis. This differs from the typical form of *Setaria lntesceus* in the lemma of the lower floret which is convex, chartaceous to cartilaginous and slightly transversely rugose.

Annual; culms erect, about 80 cm tall, branched, compressed, striate, scaberulous below the inflorescence; leaf-blades linear-lanceolate, acuminate at apex, rounded at base, 15 to 35 cm long, 6 mm wide, scaberulous to smooth beneath, scabrous on the margins; sheaths compressed, glabrous; ligule a fringe of white hairs, 1.5 mm long, fused at base. Panicle spikelike, cylindric, dense, 5 to 11 cm long, yellowish; bristles yellowish, 5 to 12 in a cluster, the longer 2 to 4 times as long as the spikelet; spikelets 3 mm long, 1.8 to 2 mm wide, ovoid, acute; first glume 1.2 to 1.5 mm long, 3-nerved, ovate, obtuse to acute at tip, cordate at base, embracing the spikelet; second glume 1.5 to 2 mm long, 5-nerved, ovate, acute; lower floret staminate with 3 stamens, or rarely with abnormal bristles, with palea; lower lemma convex, chartaceous to cartilaginous, slightly transversely rugose, 5-nerved; its palea membranaceous, equal to and as broad as the upper palea, 2-nerved, with inflexed margins; upper floret perfect; upper lemma and palea cartilaginous, strongly transversely rugose, with inflexed margins, the lemma strongly convex and 3- to 5-nerved. the palea flat and 2-nerved; lodicules cuneate, truncate; stamens 3; anthers 0.8 mm long, brown; caryopsis orbicular, grayish.

Type specimen: *Oh 8090*, Sohuksan Do, MICH. Other Korean specimen examined: Seoul (?) (*Kim, anno* 1948, MICH).

Agropyron kamoji Ohwi f. **muticum** Chung, forma nov.

A forma typica differt glumis sterilibus acutis vel acuminatis.—Specimen typicum legit Nakashima 25 Jun. 1942 in colle Poukhansan prope Seoul, in U. S. Nat. Herb. sub num. 1,964,758.

This differs from the typical form in the acute or acuminate glumes.

Type specimen: Nakashima June 25, 1942 (US 1,964,758), Poukhansan.

Ischaemum crassipes (Steud.) Thell. f. **pilosum** Chung, forma nov.

A forma typica differt lamina utrinque dense pilosa.—Specimen typicum prope locum "Cheju Do" dictum, legit collector sub num. Chungii 4843, in herbario Univ. Michiganensis.

This differs from the typical form of *Ischaemum crassipes* in the densely pilose leaf-blade.

Type specimen: *Chung's* collector 4843, Cheju Do, MICH. Other Korean specimen examined: *Taquet 3555, US.*

Poa ussuriensis Roshev. f. **angustifolia** Chung, forma nov.

A forma typica differt lamina 1.5–2 mm lata, ligula 0.3–0.5 (0.7) mm longa.—Specimen typicum legit Ohwi (num. 844) anno 1930 prope Kyongsong in provincia Hamkyong-Pukto, conservatum in U. S. Nat. Herb. sub num. 1,964,476.

This differs from the typical form in the narrower leaf-blade and the shorter ligule.

Culms compressed, glabrous, smooth or scaberulous below the nodes; sheaths compressed, glabrous, smooth or scaberulous near the node and on the keel; leaf-blades 7 to 9 cm long, 1.5 to 2 mm wide; ligules 0.3 to 0.5 or rarely 0.7 mm long; anthers 0.5 to 0.7 mm long.

Type specimen: *Ohwi 844* (US 1,964,476), Kyongsong, Hamkyong-Pukto.

Poa ussuriensis Roshev. f. **scabra** Chung, forma nov.

A forma typica differt culmis scabris infra nodos.—Specimen typicum legit Ohwi sub. num. 857, anno 1930, prope oppidum Kyongsong in provinsia Hamkyong-Pukto, in U. S. Nat. Herb. conservatum (n. 1,964,477).

This differs from the typical form in the culm which is scabrous below the nodes.

Culms compressed, 3- or 4-noded, striate, scabrous below the nodes; sheaths shorter than the internodes, compressed, keeled, striate, scabrous at least near the nodes, purplish near the base; leaf-blades about 10 cm long, 2.5 to 6 mm wide; ligules 1 to 2 mm long; panicle 14 to 18 cm long, with 3 to 5 branches below, those branches 5 to 14 cm long; glumes scaberulous on the keel, the first 1-nerved and the second 3-nerved; lemmas 5-nerved, glabrous on the intermediate nerve and between the nerves, pubescent on the lower third to half of the keel and on the lower fourth of the marginal nerves, wave-haired at base; anthers 0.8 to 1 mm long; rachilla glabrous, minutely scaberulous.

Type specimen: *Ohwi 857* (US 1,964,477), Kyongsong, Hamkyong-Pukto.

Polypogon higegaweri Steud. f. **muticum** Chung, forma nov.

Folia 4–8 cm longa, 2.5–3 mm lata. Ligula 2–4 mm longa. Panicula 6–6.5 cm longa, 7 mm lata; glumis 1.5–2 mm longis, muticis vel submuticis; lemmatibus muticis; antheris 0.3–0.4 mm longis. —Specimen typicum legis Oh sub num. 8257 in insula Sohuksan Do.

Leaf-blades 4 to 8 cm long, 2.5 to 3 mm wide; ligules 2 to 4 mm long. Panicle 6 to 6.5 cm long, 7 mm wide; glumes 1.5 to 2 mm long, awnless or nearly so; lemmas awnless; anthers 0.3 to 0.4 mm long.

Type specimen: Oh 8257, Sohuksan Do, MICH.

New combinations are as follows:

Calamagrostis arundinacea (L.) Roth var. *heterogluma* (Nakai) Chung, comb. nov. (*Calamagrostis longiseta* Hack. var. *heterogluma* Nakai in Bot. Mag. Tokyo **35:** 149, 1921.)

Diarrhena fauriei (Hack.) Ohwi var. *koryoensis* (Honda) Chung, comb. nov. (*Diarrhena koryoensis* Honda in Koryo-shikenrin-no-ippan 79, 1932.)

Miscanthus sinensis Anderss. var. *coreensis* (Hack.) Chung, comb. nov. (*Miscanthus coreensis* Hack. in Bull. Herb. Boiss. 2 ser., **4:** 531, 1904.)

Miscanthus sinensis Anderss. var. *ionandros* (Nakai) Chung, comb. nov. (*Miscanthus ionandros* Nakai in Bot. Mag. Tokyo **41:** 13, 1917.)

Miscanthus sinensis Anderss. var. *longiberbis* (Hack.) Chung, comb. nov. (*Miscanthus matsumurae* Hack. var. *longiberbis* Hack. in Bull. Herb. Boiss. 2 ser., **4:** 532, 1904.)

Miscanthus sinensis Anderss. var. *nakaianus* (Honda) Chung, comb. nov. (*Miscanthus nakaianus* Honda in Bot. Mag. Tokyo **42:** 130 & 179, 1928, also in Journ. Fac. Sci. Univ. Tokyo sec. 3, **3:** 389, 1930.)

Tripogon chinensis Hack. var. *longiaristata* (Honda) Chung, comb. nov. (*Tripogon longiaristata* Honda in Bot. Mag. Tokyo **41:** 11 & 16, 1927, also in Journ. Fac. Sci. Univ. Tokyo sec. 3, **3:** 145, 1930.)

Eragrostis pilosa (L.) Beauv. f. *multicaulis* (Steud.) Chung, comb. nov. (*Eragrostis multicaulis* Steud., Synop. Pl. Glum. **1:** 426, 1855.)

Ischaemum eriostachyum Hack. f. *stenopterum* (Hack. ex Nakai) Chung, comb. nov. (*Ischaemum anthephoroides* (Steud.) Miq. var. *stenopterum* Hack. ex Nakai in Bot. Mag. Tokyo **33:** 3, 1919.)

Polypogon higegaweri Steud. f. *demisus* (Steud.) Chung, comb. nov. (*Polypogon demissus* Steud., Synop. Pl. Glum. **1:** 422, 1855.)

Thirteen species and eleven varieties of grasses are endemic in Korea: eight species and three varieties in Northern Korea, three species and three varieties in Central Korea, two species and three varieties in Southern Korea, and two varieties in Central and Southern Korea.

Endemic grasses are as follows:

Alopecurus aequalis Sobal. var. *brachytrichus* (Ohwi) Ohwi in Hamgyong-pukto,
Calamagrostis arundinacea (L.) Roth var. *hymenoglossa* Ohwi in Hamgyong-pukto,
Calamagrostis paishanensis Nakai in Mt. Paektu, Hamgyong-pukto,
Calamagrostis subacrochaeta Nakai in Mount Nangnim, Pyongan-pukto,
Elymus mollis Trin. var. *coreensis* (Hack.) Honda in Wonsan, Hamgyong-namdo,
Festuca blepharogyna (Ohwi) Ohwi in Mt. Sullyong,
Ischaemum coreanum Nakai ex Honda in Seoul,
Miscanthus sinensis Anderss. var. *coreensis* (Hack.) Chung in Sepo, Cheju Do, and Tong Do,
Miscanthus sinensis Anderss. var. *longiberbis* (Hack.) Chung in Changwoni,
Miscanthus sinensis Anderss. var. *nakaianus* (Honda) Chung in Kangwondo,
Oplismenus undulatifolius (Ard.) Beauv. var. *elongatus* Honda in Kwangnung, Kyonggido,
Poa deschampsioides Ohwi in Mt. Duryu, Kwanmobong, and Chailbong, Hamgyong-pukto,
Poa hamhungensis Chung in Hamhung, Hamgyong-namdo,
Poa kanboensis Ohwi in Mt. Kwanmobong, Hamgyong-pukto,
Poa kumgansani Ohwi in Mt. Kumgang, Kangwondo,

Poa kyongsongensis Chung in Kyongsong, Hamgyong-pukto,
Poa takeshimana Honda in Ullungo Do,
Poa ullungdoensis Chung in Ullung Do,
Puccinellia coreensis Honda in Mokpo and Cheju Do,
Sasa coreana Nakai in Hamgyong-pukto,
Sasa quelpaertensis Nakai in Cheju Do,
Sasamorpha borealis (Hack.) Nakai var. *chiisanensis* (Nakai) Chung in Mt. Chiri,
Setaria lutescens (Weigel) Hubb. var. *dura* Chung in Sohuksan Do,
Tripogon chinensis Hack. var. *coreensis* Hack. in Chinnampo, Sorai in Whanghaedo, and Cheju Do,
Tripogon chinensis Hack. var. *longiaristata* (Honda) Chung in Cheju Do.

Distribution of the grasses in Korea and the nearest systematic and geographic relationships of endemic species are fully discussed in the *Manual*. A brief classification of the grasses by habitats and a list of the important collections of Korean grasses in four herbaria of U. S. A. are given. A map of Korea with three divisions (North, Central, and South) is included, and the latter indicates location of the important localities represented by collections in the four herbaria which have been cited.

ZOOLOGY.—*A new species of* Pararchinotodelphys (*Copepoda: Cyclopoida*) *with remarks on its systematic position.* PAUL L. ILLG, Department of Zoology, University of Washington.[1]

(Received March 15, 1955)

Important revisions of concepts long held regarding ascidicolous copepods have resulted from recent contributions of Karl Lang (1948, 1949). His family Archinotodelphyidae (1949) is significant because it presents anatomical and ecological features which illustrate transition from casually occurring associates of ascidians to anatomically modified forms reflecting ecological dependence on these host organisms as providing either shelter or nutrition. He considers this family to occupy an intermediate position serving as the directly connecting link between the families Cyclopinidae and Notodelphyidae. The whole series then readily conforms to the long existing definition of the Cyclopoida Gnathostoma. The use of the order Notodelphyoida Sars is accordingly abandoned by Lang, and he further points out the logic of incorporating various ascidicolous copepods, other than notodelphyids, but included by Sars in his suborder, in some of the other subdivisions of the Cyclopoida. Two monotypic genera are recognized by Lang in the new family. The species here to be described is a congener of *Pararchinotodelphys phallusiae* (Hansen), 1923.

[1] Acknowledgment is made of technical assistance furnished through a research grant from Initiative 171 Fund, State of Washington.

Family ARCHINOTODELPHYIDAE Lang, 1949
Pararchinotodelphys Lang, 1949

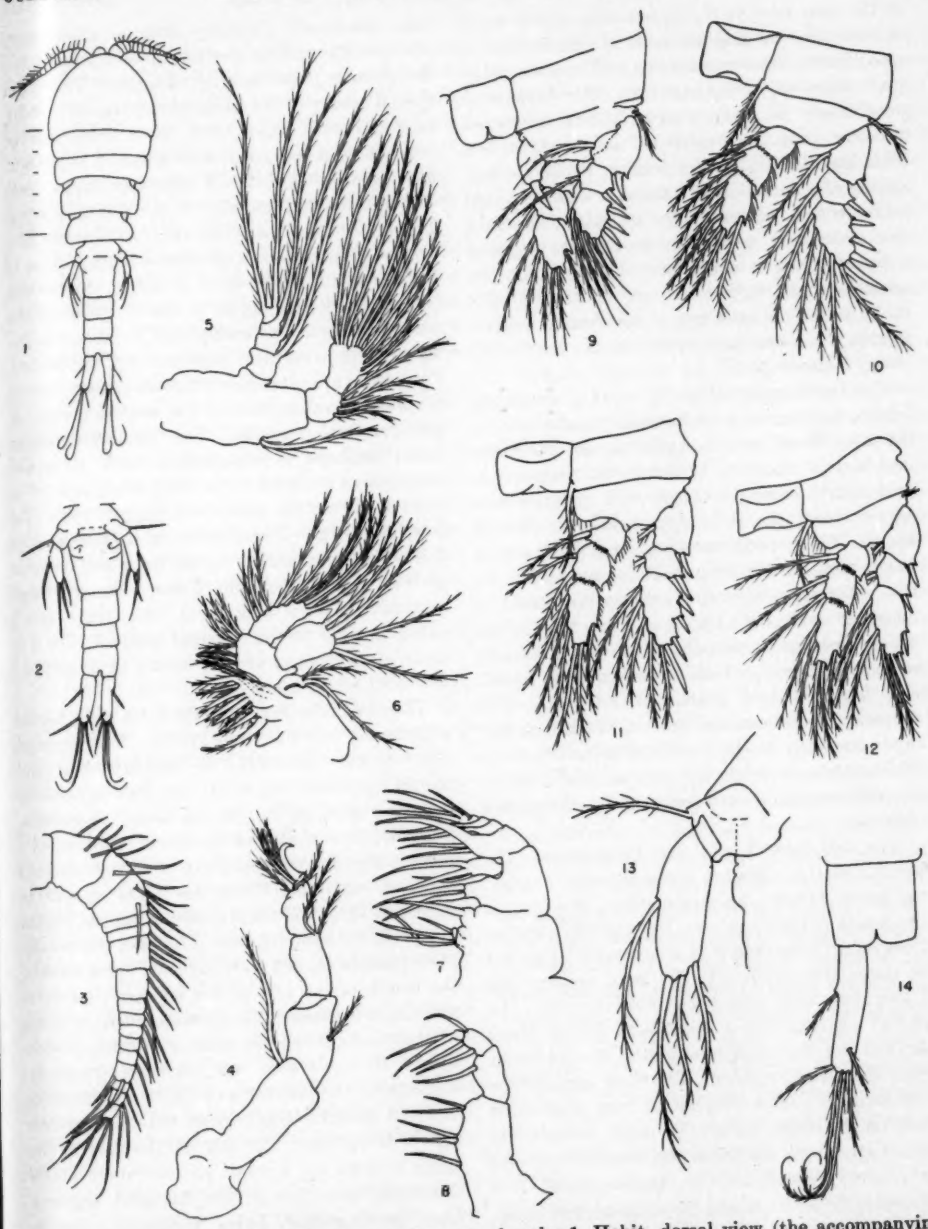
The urosome in the female consists of the segment of the fifth legs, a complex genital segment, representing fusion of 1 anatomically thoracic segment and one anatomically abdominal segment, and three free abdominal segments. The antennule consists of many segments, 16 or 17 being the number so far known. The antenna is 4-segmented. The mandible palp has a 2-segmented endopodite and 4-segmented exopodite. The maxilliped is 3- or 4-segmented. The natatory legs have both rami 3-segmented. The fifth legs are 2-segmented; four setae are borne on the terminal segment, one on the basal segment at the distolateral corner. Type species, *P. phallusiae* (Hansen), 1923.

Pararchinotodelphys gurneyi, n. sp.
FIGS. 1–14

Specimens examined.—4 females, all adult; from branchial cavities of specimens of *Styela partita* (Stimpson) (U.S.N.M. no. 3181), off Marthas Vineyard, Mass., *Fish Hawk* station 940, August 4, 1881, depth 134 fathoms.

Types.—Holotypic female, U.S.N.M. no. 97608; paratypes no. 92536; all from the one known collection.

Description.—FEMALE (Figs. 1–14): The body presents in outward aspect (Fig. 1) the generalized cyclopoid characters, such as those seen



FIGS. 1–14.—*Pararchinotodelphys gurneyi*, n. sp., female: 1, Habit, dorsal view (the accompanying scale represents 0.5 mm); 2, urosome, ventral view; 3, antennule; 4, antenna; 5, mandibular palp; 6, maxillule; 7, maxilla; 8, maxilliped; 9, first leg; 10, second leg; 11, third leg; 12, fourth leg; 13, fifth leg; 14, caudal ramus.

in the near relative *Cyclopina*. The cephalosome consists of the long segment of the head and maxillipeds; there is a free segment for each of the four pairs of swimming legs. The metasome accordingly is 5-segmented. The 5-segmented urosome (Fig. 2) consists of the somite of the fifth legs, a long genital somite, probably consisting of a posteriormost thoracic segment fused with the first segment of the abdomen, and three free abdominal segments, counting the segment supporting the caudal rami, which includes the anal aperture. Egg-sacks were not found. The structure of the urosome of the female demonstrates the fully adult condition. No incubatory cavity is developed.

The antennules (Fig. 3) are of moderate length, much greater in diameter basally than at the tip. There are 16 segments, of which the proximal is longest, although no segment is particularly elongate. There is a short second segment and the third approaches the first in length. These proximal three segments are of fairly uniform thickness and are succeeded by two short segments, each sharply graduated in diameter so that the appearance has a telescope effect tapering the appendage to the sixth and seventh segments, which are subequal in length and fairly sharply graduated in width. The succeeding segments are subequal in length and taper gradually to the narrow terminal segment. The setation is relatively profuse and exhibits no differentiation of particularly distinctive elements.

The antennae (Fig. 4) are 4-segmented. The lengths of the segments are graduated distally, the basal segment being somewhat over double the length of the distal one. In available preparations some of the details of ornamentation cannot be thoroughly made out. The basal segment has 1 long, fine inner seta, borne subterminally. The second segment has a single seta placed about midway on the margin opposite the setiferous edge of the basal segment. The third segment has two (or three) setae, originating from a common base on the distal margin. Forming an elaborate articulation with the tip of the terminal segment is a heavy, spirally curved, tapered hook. This structure is accompanied by three curved setae, in length about equal to the hook, and inserted in the articulating region. There are at least three additional minor subterminal setae.

The base of the mandible includes an expanded coxa produced medially into a masticatory process. The medial portion of this process is a flat dentate plate, heavily chitinized. The upper medial corner of the plate terminates in a stout, tapered tooth, and there is a wide curved emargination between this tooth and a lower saw-like row of several closely spaced subequal teeth which form the remainder of the medial margin. The palp of the mandible (Fig. 5) consists of a basipodite and two rami. The ornamentation of the basipodite consists of a single, slight seta inserted somewhat distal to the midpoint of the medial margin. The endopodite is placed terminally on the elongate basis and is 2-segmented. Four setae are arranged in a close-spaced row on the distolateral portion of the medial margin of the proximal segment. The somewhat larger distal segment is ornamented with 10 setae, arranged in a compact row from the midpoint of the medial margin across the slightly expanded terminal margin. The endopodite is inserted considerably subterminally on the basis and consists of four segments. Each of the three proximal segments bears a long stout seta; there are 2 subequal setae on the terminal segment. The five setae of the ramus are graduated in length; all are stout and plumose.

The maxillule (Fig. 6) is the most complicated structurally of the mouthparts. The greatest mass of the appendage is the expanded and foliose proximal segment of the apparently bimerous protopodite, which seems to include, however, more than 2 of the several theoretically present protopodite segments of the generalized copepod maxillule. There are what appear to represent three endites disposed along the medial margin of the basal segment. The most proximally placed endite takes a wide insertion along most of the length of the axis of the segment and flares to form an expanded plate bearing medially along its margin eight tapered setae of varying proportions, all of which are directed medially. Proximally, the insertions of the setae tend to be removed progressively farther onto the anterior face of the process. Overlain by the flare of this major process are 2 small protuberances at the distal medial corner of the flattened segment. Each protuberance bears a slender, distally directed seta. The three setiferous processes of the segment would seem to represent 3 laciniae and indicate a coalescence of three archetypical segments to produce the arrangement here seen.

The basal segment supports a small lateral protuberance which seemingly represents a coalesced epipodite. This prominence bears two markedly unequal setae. The principal seta is elongate and tapering and proximally placed. It is directed proximally. The distal seta, which originates from a base very closely placed to that of the principal seta, is slender and short.

The distal segment of the protopodite is expanded medially and distally so that the apparently lateral margin bears both the rami of the limb. The medial margin of the segment supports two groups of setae, a proximal couple and a more distal group of four.

The endopodite is monomerous, tapered, with a more or less straight lateral margin and curving medial margin. Along most of the length of the medial margin and across the narrow apex are set 10 graduated slender setae. The apical setae are the longest. The exopodite is subquadrate and the wide distal margin supports four uniformly spaced, long, subequal setae, all profusely plumose.

The maxilla (Fig. 7) is 6-segmented. The basal segment is broadly expanded, although very flat, and bears two endites, each of which is somewhat suppressed to form a conical protuberance. The proximal prominence bears an apical group of four setae, of graduated size and with an intricate, closely spaced pattern of articulation. The distal endite has a single seta. The second segment, which narrows apically, bears two projections. A proximal conical endite, like those of the proximal segment, bears two setae. Distally there is a distinctly articulated rectangular arthrite which supports two long subequal setae and a much finer, shorter seta, the three arranged linearly along the medial margin.

The third segment is produced medially as a heavy, tapering, somewhat curved hook. There is no articulation of this structure with the main mass of the segment. Two slender subequal setae are borne on the hook-process, inserted at a point which should approximate the medial edge of the segment.

The distal portion of the appendage is a minute, trimerous cone, tapered apically. The two more proximal segments each bear a medial seta. The apical segment bears four setae, three terminal and one borne on the surface of the basal portion of the segment.

The maxilliped (Fig. 8) is tetramerous. The basal segment much exceeds in mass the combined remainder. Five setae are inserted into a pattern composed of a proximal solitary seta, midmargin couple and distal couple, all on the medial margin of the segment. The second segment is about half the width of the first segment and its ornamentation consists of a single long seta set subterminally on the medial margin. The third segment is still slenderer and shorter than the second and supports two medial setae and a seta at the distolateral corner. The minute terminal segment has 2 long slender apical setae.

The 4 pairs of swimming legs are generalized in plan and seem to exhibit no modifications for other than a free-living existence. The segmentation and armature of these appendages may be represented as follows: Setae are designated in Arabic numerals following designation of spines in Roman. The segments of each ramus are accounted for in order from the basal segment distally. The armatures of the terminal segments are designated by listing in order lateral elements —terminal elements—medial elements. First exopodite I-1; I-1; III-I, 1-3; first endopodite 0-1; 0-1; 1-2-3. Second exopodite I-1; I-1; III-I, 1-4; second endopodite 0-1; 0-2; 1-2-3. Third exopodite I-1; I-1; III-I, 1-4; third endopodite 0-1; 0-2; 1-2-3. Fourth exopodite I-1; I-1; II-I, 1-4; fourth endopodite 0-1; 0-2, 1-2-2.

In the first legs (Fig. 9), it was impossible in the available material to determine whether the usual medial coxal setae are present. The legs of the pair are united by a well-developed intercoxal plate. The basipodite exhibits an oblique distal margin, the lateral edge of the segment being of such slight extent as barely to provide insertion for its slender seta. The medial margin is long, accommodating the marked distal prolongation which supports a stout, tapered, curved spine. Each of the rami consists of three subequal segments. The spines of the two proximal segments of the exopodite are roughly equal in dimension with the three subequal marginal spines of the distal segment.

The second legs (Fig. 10) consist each of a bimerous protopodite and of trimerous rami, the coxae yoked by the intercoxal plate. Each coxa bears a slender, relatively short seta at the distal medial corner. The very short lateral margin of the basis is set with a short, slender seta.

The third legs (Fig. 11) are almost identical in

proportion and ornamentation with the second legs.

The fourth legs (Fig. 12) consist of bimerous protopodites and trimerous rami. The intercoxal plate unites the paired legs. Each coxa bears a slender, rather short medial seta. Each basis bears a slender lateral seta.

The fifth legs (Fig. 13) are bimerous. The basal segment, probably representing the protopodite, although the exact homology is not clear, equals about half the bulk of the distal segment. The presence of a slender seta on the distolateral corner of the proximal segment lends weight to the established practice of referring to it as the basipodite. The distal segment is a flat plate, elongate and with its width about a third of its length. A seta is set at about the midpoint of the lateral margin, there is a stout long apical seta and 2 slenderer, subequal setae arranged subterminally rather close together on the apical fifth of the medial margin.

The caudal rami (Fig. 14) are of generalized cyclopoid aspect, the length of each about five times its greatest width. Basally each is more expanded than distally, with the lateral edge exhibiting a sharp emargination about a third of the length of the ramus distal from the base. The emargination is set with a slender seta, in length equal to about half that of the ramus.

There are four apical setae, the central two of the quartet long and stout. These measure about 1.5 times the length of the ramus. In the available specimens the exact relative lengths of these 2 setae could not be made out. The slender medial seta is somewhat exceeded by the lateral seta. A slender seta is set on the medial portion of the dorsal surface of each ramus subterminally about one-eighth the length of the ramus. The ciliation of all the setae is well developed.

No male has been found.

Remarks.—In comparing the present species to *P. phallusiae*, a number of differentiating characters are established which have been made use of in some slight revisions of the generic definition. In *P. gurneyi* the antennule is 16-segmented, that of *P. phallusiae* is apparently 17-segmented. The antennae seem basically similar in the two species but the terminal prehensile hook in *P. gurneyi* is much stouter and more highly developed. The mandibles correspond in the two species, but in *P. gurneyi* the exopodite is shorter and the segments more compressed together. The maxillule is somewhat more complicated in *P. gurneyi* and the protopodite bears a medial setiferous projection not accounted for in *P. phallusiae*. The maxillae cannot adequately be compared in the two species on the basis of available information. The maxilliped in *P. phallusiae* is 3-segmented evidently exhibiting a coalescence of terminal segments which are free in the tetramerous appendage of *P. gurneyi*.

The first three swimming legs are not described for *P. phallusiae*. In the fourth legs the formula for armature is apparently exopodite I-1; I-1; 1-4; endopodite 0-1; 0-2; 1-2-2, which would correspond exactly to *P. gurneyi*. The fifth legs in the two species are essentially similar except that in *P. gurneyi* the medial seta of the distal segment is much more nearly subterminal in position. Body segmentation in the two species corresponds in general.

It is necessary here to consider also the species *Pseudocyclopina belgicae* (Giesbrecht). Lindberg (1952) has pointed out the close relationship of this copepod to *Pa. phallusiae*; in fact he has made the two species congeneric. Agreement with this view would have to shift generic assignment of *Pa. phallusiae* and *Pa. gurneyi* to Lang's prior genus *Pseudocyclopina* (1946) and in turn might then logically require removal of the genus from the Cyclopinidae to the Archinotodelphyidae.

In antennular segmentation *Pa. phallusiae* and *Ps. belgicae* correspond; *Pa. gurneyi* differs by possession of 1 less segment. The difference is scarcely to be regarded as other than of specific importance. In the antenna *Ps. belgicae* lacks the inner seta of the basal segment and in the two terminal segments shows neither the tendency to shortening of the segments nor development of prehensile elements among the terminal armature, all of which features characterize the other two species.

The mandible of *Ps. belgicae* exhibits the distinctive cyclopinid feature of reduced setation of the segments of the endopodite, possessing three setae on the basal segment, six on the distal segment, contrasting thus with the other species. The maxilliped of *Ps. belgicae* is more distinctively cyclopinid in the possession of seven segments. The development of the two basal segments is more or less comparable to that in the three archinotodelphyid species.

The first leg is not known for *Pa. phallusiae*.

In possession of two setae on the second segment of the endopodite *Ps. belgicae* presents a notable difference from *Pa. gurneyi*. The presence of three spines on the terminal segment of the exopodite in *Ps. belgicae* as compared to four such spines in *Pa. gurneyi* is a less distinctive difference. The fourth leg corresponds in the 3 species but might further be said to conform to a widespread condition found among cyclopinids and notodelphyids in general, at this level offering no significant clue to generic affiliation. In the fifth leg all three archinotodelphyids agree and *Ps. belgicae* markedly disagrees in the possession of two setae on the basipodite in the female.

Taxonomic separation of *Ps. belgicae* is then readily made on the basis of differences in the armature of the mandibles, segmentation of the maxilliped, armature of the first legs and in the structure of the fifth legs. These differences are at a level customarily held to be of generic rank in the treatment of related copepods. Several still unknown quantities leave room in certain measure for a future reopening of the issue. Comparison of the maxillules and maxillae of *Ps. belgicae* and *Pa. phallusiae* must await redescription of the species. Description of the first leg of *Pa. phallusiae* is also a desideratum. Further, a most striking sexual dimorphism in *Ps. belgicae* separates it strongly from all cyclopinids. No male is yet known from any of the three archinotodelphyid species. However, the present conclusion must be to retain Giesbrecht's species in systematic separation and *Pseudocyclopina* must currently be regarded as a genus placed without any undue difficulty in the family Cyclopinidae.

The differentiation of *Pararchinotodelphys* from *Archinotodelphys*, as set forth by Lang (1949) is readily maintained. The difference in segmentation of the urosome in the female, the difference in number of setae of the basal antennal segment, the differences in segmentation of the maxilla and maxilliped and the possibility of difference at generic level of the armature of the maxillule are here recognized as the basic considerations.

The distribution of taxonomic characters through the cyclopinids, archinotodelphyids and notodelphyids presents at the current stage of information certain puzzling aspects. Discussion of some of these is pertinent in explanation of the systematic disposition applied in the present study. With reference to body segmentation, two important characters found among archinotodelphyids deserve analysis. The first character is the condition of the thoracic segment of the first pair of swimming legs. All three species exhibit this as a free segment. In cyclopinids this segment is typically fused in a cephalosome complex. Among notodelphyids this segment may be free or fused. In *Notodelphys* it probably is typically free (cf. Stock, 1951, p. 1). The claim has frequently been made that fusion is the primitive condition. Evidence, however, is so contradictory and confusing that it seems impossible to assign this character as a criterion at a high level of systematic significance. It seems to be a character of sufficient plasticity as to have no pertinence at other than the specific or generic level.

The segmentation of the urosome presents an ambiguous morphological situation. The formation of a "genital segment" in the female by coalescence of the last thoracic segment with the first abdominal segment is a character of widespread distribution through the cyclopoids. Information from development is only fragmentary but the indication seems to be that free and separate segments appear as a first stage with the fusion secondary and appearing at the last molt. More information on the subject is needed. The very extent of occurrence of this fusion lends strong support to the view of it as a primitive character. The typical condition among the cyclopinids seems to be fusion. It simply is not possible to say, however, that no female cyclopinid can possess the alternative condition of completely free segments. In *Notodelphys* females the separated genital segment is typical. In some other notodelphyids with some otherwise primitive characters, as illustrated by *Doropygopsis*, the segments are fused. In *Pararchinotodelphys*, the segments are fused, therefore more like the cyclopinids; the segments are free in *Archinotodelphys*. It becomes almost impossible here to say which of the conditions must be the primitive one; and, further, whether the primitive state in this one family is the same as that for the entire cyclopinid-archinotodelphyid-notodelphyid series.

Morphological features of some of the appendages offer equally puzzling patterns of distribution. The species of *Pararchinotodelphys*,

in bearing a single medial seta on the basal antennal segment, conform to a generally prevalent condition among the cyclopinids. Information is not available as to whether the condition is invariable in the family, but no contrary instance seems to occur among available records. In *Notodelphys* and some other notodelphyid genera, two setae, conforming very well to the condition in *Archinotodelphys*, occur here.

If long-standing concepts of the structure of the maxillule are correct, the most primitive condition now known in the lineage could with almost equal justice be assigned to a notodelphyid, *Doropygopsis*, or to an archinotodelphyid, *Pararchinotodelphys gurneyi*.

In the latter, the correspondence with Gurney's scheme (1931, p. 57) of the generalized maxillule of the Copepoda is of interest. The elements of the most primitive grade of organization of the appendage would seem to be present here although in a different arrangement than is seen in the generalized types of other major sections of the copepods. The elements of the four segments of the basic protopodite would here be found arranged as two segments. The proximal segment bears three of the possible four laciniae internae and the single epipodite. The distal segment bears setae presumably representing a single endite, and articulates with the endopodite and exopodite. (What would explain the subdivision into two groups of setae as here seen, is difficult to explain in view of considering that a single lacinia interna supposedly is involved). In the main, however, this arrangement furnishes a neat correspondence to the basic calanoid arrangement and is in these regards the most primitive example of the maxillule among the Cyclopoida.

By comparison the maxillule of *Doropygopsis* would offer on one line of structural evidence a phylogenetic advance over the condition just described; on still another line, it exhibits what is seemingly a more primitive grade of construction. The medial setae and protuberances in this maxillule seem to offer grounds for interpretation as representing one less endite than would be found in *P. gurneyi*. In *Doropygopsis* there is the medial group of masticatory setae, a single seta inserted on a more distal protuberance, and finally a distal series of setae apparently referable to the basipodite. However, on this appendage the endopodite is bimerous. This condition is not known at all among the cyclopinids or archinotodelphyids so its occurrence here, as well as in *Pachypygus*, among the notodelphyids is difficult of explanation. It would contradict all experience with specializations among crustacean appendages to maintain that here the addition of a segment and addition of a number of setae would represent an advance in specialization rather than a primitive condition.

The endopodite is bimerous in the primitive calanoid maxillule and combination of the two lines of occurrence in *Doropygopsis* then would indicate that such would be the case in the archetypical cyclopoid, although there is no known example combining the primitive features of *Pararchinotodelphys* and of *Doropygopsis*. In *Canuella*, as an example of a primitive harpacticoid maxillule (Gurney, 1931, fig. 44), the appendage is seemingly more generalized than any known among cyclopoids and shows satisfactory correspondence to the archetypical condition hypothesized above.

In the case of the maxilla, a case much paralleling that of the maxillule occurs, but in less extreme measure. Reference to Sars (1918, pls. 8, 10) indicates that the cyclopinids *Pterinopsyllus insignis* Brady and *Cyclopinella tumidula* Sars exhibit in this appendage characters which would customarily be regarded as primitive. Strong indications of a 6-segmented condition are present. The most distal portion of the appendage is a small trimerous unit, the apical segment bearing 4 setae. Reductions in this appendage are characteristic for the majority of cyclopinids. Among notodelphyids *Doropygopsis* exhibits the best approach to the 6-segmented condition. Among species of *Doropygus* the terminal segmentation and armature are most highly developed. Assembling these characters would produce a grade of structure approaching the basic cyclopinid condition. The condition in *P. gurneyi* would approach this generalized structure. In *Archinotodelphys* the segmentation is considerably suppressed and the armature reduced.

In the segmentation and armature of the swimming legs, the archinotodelphyids tend to resemble the cyclopinids closely. Their characters in this regard would enable them to fit with no question among the species in the parental family. Paradox again enters this situation when among the notodelphyids instances are found to occur in which the number of elements of

armature for a given segment exceeds that found for the same member in any archinotodelphyid. This would be illustrated by some *Doropygus* species, in which the terminal segment of the fourth exopodite bears four spines and five setae. As representative of the cyclopinids exhibiting this armature there seems to be known only *Paracyclopina nana*, a species admittedly well removed from a primitive position in the family by the reduced condition of other of its appendages. Perhaps this form lies close to the lineage of the archinotodelphyids, however.

The characters of the archinotodelphyids most strongly suggesting the intermediate position of the family between cyclopinidae and notodelphyidae are the antennae, the maxillipeds and the fifth legs.

In the antenna the bimerous terminal portion characteristic of the archinotodelphyids, and corresponding well to the cyclopinid condition, has never been found in notodelphyids. In all the latter the appendage is markedly more modified in segmentation, but as we have seen above, with reference to the setae of the basal segment, more primitive than in a typical cyclopinid.

The maxillipeds are not completely satisfactory as possibly directly ancestral structurally to the appendages found in the descendent family. However, in rough outline they indicate what the archetypical condition might have been with regard to segmentation. Indications as to the evolutionary development of the setal armature are not apparent.

In the Archinotodelphyidae, with the small number of 3 known species, the group as a whole exhibits a complex of primitive and advanced characters with no one member corresponding to the demonstrable archetypical requirements. A similar distribution of characters occurs in the obvious parental group, the Cyclopinidae, where in various members advanced characters combine with primitive, so that again no actual archetype occurs as a reality. Further, the descendent group of the Notodelphyidae repeats again the same combination. The situation is carried to its extreme by the fact that for various of the characters involved, the most primitive expression so far found has been in a representative of the notodelphyids, by common consent the most advanced group in the series. Our extension of knowledge among these groups has reenforced our idea as to what the archetype for each and for all must have been, but these interesting creatures must still be numbered among the missing.

The foregoing discussion leads to the important decision as to the proper systematic treatment of the lineage under consideration. A most significant implication immediately appears, in that combinations of characters take great importance in here defining the taxonomic categories. By taking characters singly, logical application would most aptly lead to inclusion of all the cyclopinids, archinotodelphyids and notodelphyids within a single family. The naming of such a group would alone be a most unfortunate task to assign to any one. To submerge the historically significant implications of either of the genera *Notodelphys* or *Cyclopina* in deference to the other on any grounds should certainly lead to most aggravated nomenclatorial unpopularity. Further, such consideration of individual characters as are already available leads to the strong suspicion that the cyclopinids, archinotodelphyids and the notodelphyids are each polyphyletic as they now stand. The recent intensive fractionation of the cyclopinids in rapidly successive treatments by authors working with them would seem to bear out this point. There will doubtless be an eventual reconciliation of these groups within a single systematic category. By conventional applications within the classification of the copepods, however, it does not seem likely that the designation of this ultimate synthetic group will be at the familial level. Present lumping at this level then would be undesirable.

For present practice, as an alternative, the Archinotodelphyidae could be returned to the Cyclopinidae, retaining the Notodelphyidae in familial separation. This would involve only the submergence of a name of but a few years' standing. Such taxonomic treatment of these organisms is in line with the treatment of Lindberg. To qualify as perfectly acceptable cyclopinids, the 3 archinotodelphyid species would require little anatomical alteration, but actually considerably more than was pointed out in Lindberg's comparison of *P. phallusiae* (the only archinotodelphyid then known) with *Pseudocyclopina belgicae*.

The familial status of the Notodelphyidae is readily defended; they do present a complex of

distinctive characters. No known notodelphyid antenna shows the subdivision of the terminal portion into the clear-cut segments found throughout the cyclopinids and archinotodelphyids. The extremely high development of the terminal prehensile hook of notodelphyids is not equalled in the other groups. The maxilliped presents a difference of organization, especially with regard to the profuse setal armature on the basal segment in the notodelphyid. The fifth legs are distinctive in basic plan. Finally, the dorsal brood pouch is a feature which is universal in notodelphyids and unknown in the other groups. This series remains then a fairly strongly separated one.

A final consideration must be added. Lindberg's classification was proposed without his having opportunity to consider thoroughly the family Archinotodelphyidae (cf. Lindberg, 1952, footnote, p. 318). This family is now on the record and the definition is an adequate one. The addition of a new species has demonstrated, in the reappraisal of defining characters that there is strong evidence for a natural group here, defined by a complex of characters. The characters show overlapping in two directions, some occurring in the antecedent group, some in the descendent family. No purely archetypical species occurs in any one of the 3 separable lineages. Nor does there occur an actual transitional species for either of the gaps in continuity of distribution of the characters. The belated recognition of the existence of cyclopinids as forerunners of notodelphyids and the recent discovery of the archinotodelphyids combine to bring about the situation where the ultimate offshoot group is much better known anatomically and the range of variations more exhaustively explored than is the case for the parental series. Further, the number of genera and of species described in the notodelphyids exceeds those of both the other families. On the basis of these features, with the strongly reenforcing conviction that a considerable majority of species remains undiscovered in this whole assemblage, the present treatment then maintains the separation of the 3 families.

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ZOOLOGY.—*The isopod genus* Chiridotea *Harger, with a description of a new species from brackish waters.* THOMAS E. BOWMAN, U. S. National Museum. (Communicated by Fenner A. Chace, Jr.)[1]

(Received January 31, 1955)

During the examination of samples collected by the Shad Investigations of the U. S. Fish and Wildlife Service from 1937 to 1941, numerous specimens of an undescribed valviferous isopod of the genus *Chiridotea* Harger, 1878, were discovered. In this paper the new species is described, and certain additions and corrections are made to published accounts of the two previously known species of the genus.

[1] Published by permission of the Secretary of the Smithsonian Institution.

Chiridotea Harger, 1878

Examination of the three species has made it possible to give the following revised definition of the genus (family and subfamily characters omitted):

Mandible without molar. Inner lobe of first maxilla bearing one long, plumose seta and a minute seta. Palp of maxilliped formed of three segments; lateral margins of the two distal segments fringed with fine setae. Epimeral plates distinct on pereion somites 2–7, their free margins spinose. Propodus of pereiopod 1 somewhat larger than that of pereiopod 2 or 3. Pereiopods 1–5 of female with oostegites. Pleotelson composed of four somites, with lateral sutures of another partially coalesced somite. Medial sternal process of first somite of pleon bearing long spines. Inner ramus of uropod about half or a little more than half as long as outer ramus. Type, by original designation, *C. coeca* (Say).

Members of this genus are small species, known only from the east coast of the United States and Canada, from Florida to Nova Scotia, on sandy bottoms.

The most closely related genus, *Saduria* Adams,[2] differs from *Chiridotea* in that the mandible possesses a molar; the inner lobe of the first maxilla bears two long setae and a minute seta; the palp of the maxilliped is formed of 5 segments; the propodus of pereiopod 1 is about the same size as those of pereiopods 2 and 3; the inner ramus of the uropod is much less than half as long as the outer ramus. Members of this genus are large species, limited to arctic and subarctic waters.

KEY TO THE SPECIES OF CHIRIDOTEA

1. Flagellum of antenna 2 much shorter than peduncle, 5 segmented; antenna 1 nearly as long as antenna 2 ..... *C. coeca*
   Flagellum of antenna 2 longer than peduncle, 8–12 segmented; antenna 1 much shorter than antenna 2 2
2. Posterior margin of dactyl of pereiopod 1 armed with strong spines; pleotelson as in Fig. 2 *j* ..... *C. tuftsi*
   Posterior margin of dactyl of pereiopod 1 armed with a few setae; pleotelson as in Fig. 1 *a* ..... *C. almyra*, n. sp.

[2] The name *Mesidotea* Richardson, 1905, now commonly applied to this genus, can no longer be used, since there are two older available names: *Idotaega* Lockington, 1876, p. 44, and *Saduria* Adams, in Sutherland, 1852, appendix, p. cevii.

Chiridotea coeca (Say)

Fig. 2, *b*, *e*, *i*

Idotea coeca Say, 1818, pp. 424–425.—Gould, 1841, p. 337.
Idotaea caeca Say, Gould, in Hitchcock, 1835, p. 29.
Idotea caeca Say, Milne-Edwards, 1840, p. 131.—Guérin-Méneville, 1843, p. 35.—DeKay, 1844, p. 42.—White, 1847, p. 94.—Verrill and Smith, 1874, p. 340 (46), 569 (275), pl. 5, fig. 22.
Chiridotea coeca (Say), Harger, 1878, p. 374; 1879, p. 159; 1880, pp. 338–340, pl. 4, fig. 16–19.—Richardson, 1901, p. 539.
Chiridotea coecas (Say), Richardson, 1900, p. 226.
Chiridotea caeca (Say), Richardson, 1905, pp. 353–354, fig. 380–381.—Racovitza and Sevastos, 1910, p. 195.—Collinge, 1918, pp. 73–74, pl. 7, fig. 1.
Glyptonotus caecus (Say), Miers, 1881, pp. 17–18.

Diagnosis.—Lateral margins of head with U- or V-shaped clefts, the anterior margins of the clefts often bearing plumose setae; head produced into quadrate lobes anterior to the clefts. Antenna 2 only slightly longer than antenna 1; flagellum with 5 segments. Propodus of pereiopod 1 more robust than in the other species; greatest width a little more than ⅔ the length; lateral surface bearing a few long setae. Pleotelson narrowing gradually in basal half, more abruptly in terminal half. Length, excluding antennae, up to 13 mm.

Range.—From Florida to Halifax, Nova Scotia, on sand bottoms, usually intertidally, but occasionally found as deep as 17 fm. The collections of the National Museum contain specimens from as far south as Beaufort, North Carolina. Inclusion of Florida in the range is based on Say's statement, "... found as far south as Florida." Say gave no information about the type locality.

Chiridotea tuftsi (Stimpson)

Fig. 2, *a*, *c*, *j*

Idotea tuftsii Stimpson, 1883, p. 39.—Verrill and Smith, 1874, p. 340 (46), 569 (275).—Verrill, 1874, p. 362.
Chiridotea tuftsii (Stimpson), Harger, 1878, p. 374; 1879, p. 159; 1880, p. 340–341, pl. 4, fig. 20–23.—Richardson, 1900, p. 226; 1901, p. 539; 1905, p. 354–355, fig. 382–383.—Racovitza and Sevastos, 1910, p. 195.—Collinge, 1918, p. 74, pl. 7, fig. 2.
Glyptonotus tuftsii (Stimpson), Miers, 1881, p. 18–19.

Diagnosis.—Lateral margins of head with V-shaped clefts; head produced into quadrate lobes anterior to the clefts. Antennae 2 more than twice as long as antenna 1; flagellum of 11–12

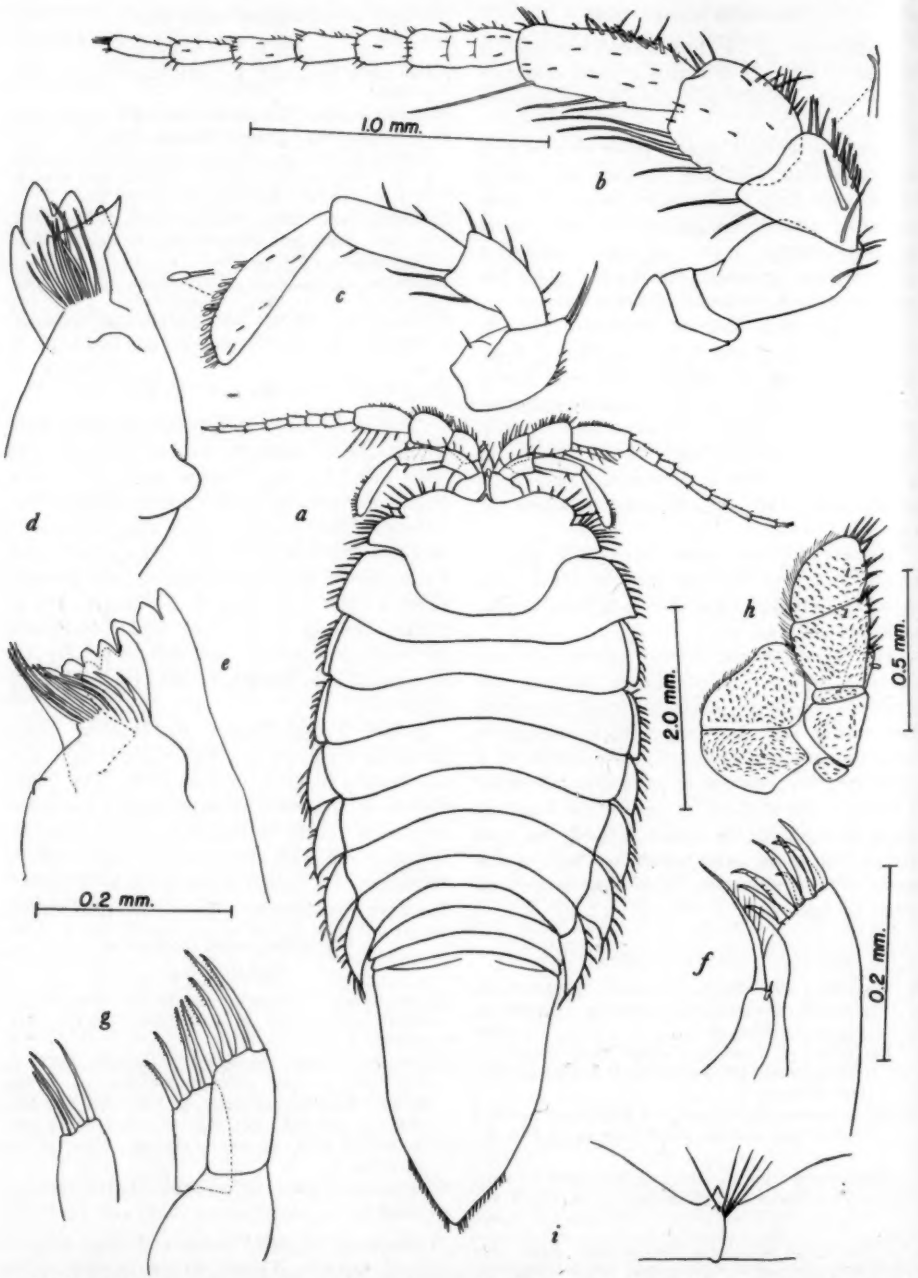

FIG. 1.—*Chiridotea almyra*, n. sp., male paratype: *a*, Dorsal view of entire animal; *b*, antenna 2, dorsal; *c*, antenna 1, dorsal; *d*, right mandible, distal portion; *e*, left mandible, distal portion; *f*, maxilla 1; *g*, maxilla 2, inner plate displaced; *h*, maxilliped; *i*, penis and medial sternal process of first somite of pleon, ventral view. *b* and *c*, same scale; *d*–*g*, same scale.

segments. Propodus of pereiopod 1 a little more than half as wide as long, lateral surface with a few short spines; dactyl armed with strong spines on posterior margin, the distal ones longer. Pleotelson tapering evenly from base to posterior end, so that its basal half appears relatively

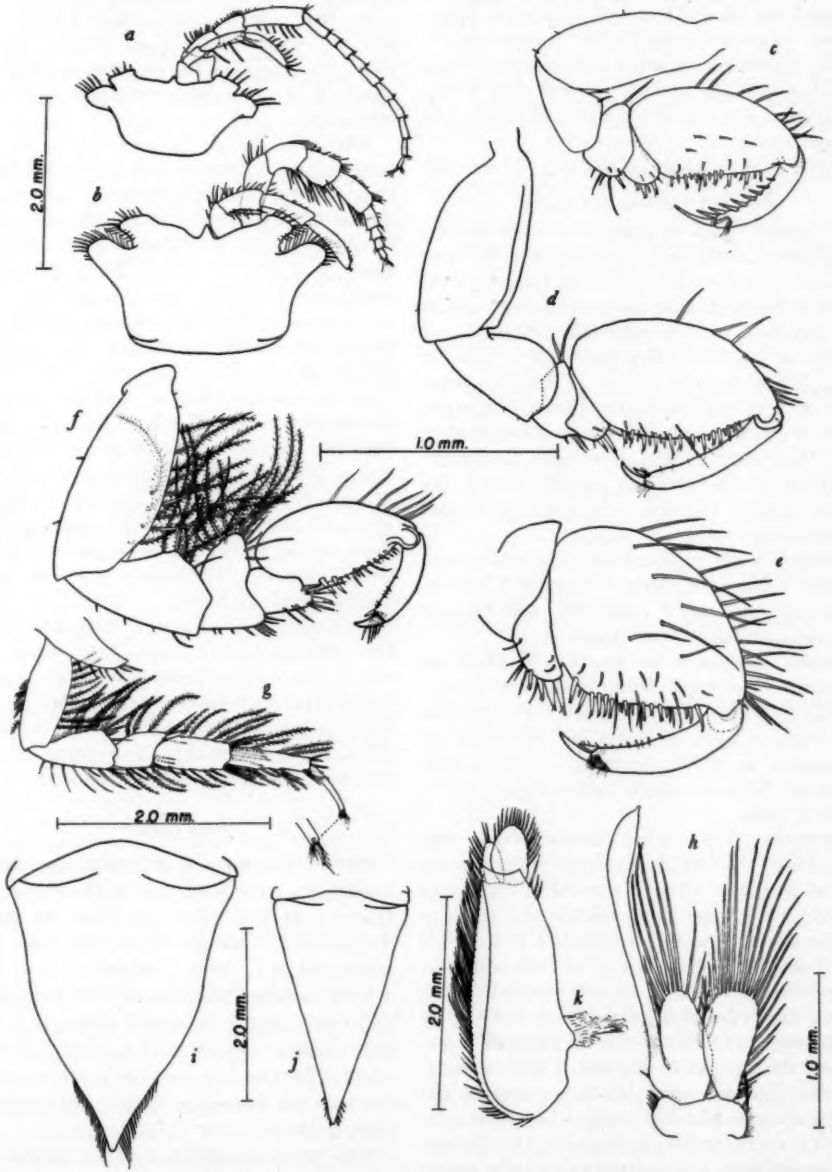

FIG. 2.—*Chiridotea almyra*, n. sp., male paratype; *C. coeca* (Say), male, from Cohasset, Mass., U.S. N.M. no. 30195; *C. tuftsi* (Stimpson), male, from S.E. Amherst Island, Gulf of St. Lawrence, U. S. N. M. no. 63744: *a*, *C. tuftsi*, head, dorsal view; *b*, *C. coeca*, head, dorsal view; *c*, *C. tuftsi*, pereiopod 1; *d*, *C. almyra*, pereiopod 1; *e*, *C. coeca*, pereiopod 1, distal segments; *f*, *C. almyra*, pereiopod 2; *g*, *C. almyra*, pereiopod 7; *h*, *C. almyra*, pleopod 2; *i*, *C. coeca*, terminal part of pleotelson; *j*, *C. tuftsi*, terminal part of pleotelson; *k*, *C. almyra*, uropod. *c–f*, same scale; *i–j*, same scale.

narrower than in the other two species. Length, excluding antennae, 5–6 mm.

Range.—Long Island Sound to the Gulf of Saint Lawrence (Amherst Island). The type was dredged in 10 fathoms, off Cheney's Head, Grand Manan Island, New Brunswick. *C. tuftsi* inhabits deeper water than *C. coeca*, being found in bottoms of fine, uniform sand (Tait, 1927), from the level of low tide to a depth of 30 fathoms.

Chiridotea almyra,[3] n. sp.

Fig. 1, *a–i*; fig. 2, *d*, *f*, *g*, *h*, *k*

Diagnosis.—Lateral margins of head divided by V-shaped clefts; anterior to the clefts the head is evenly rounded, not produced into quadrate lobes. Antenna 2 about twice as long as antenna 1; flagellum of 7–9 segments. Propodus of pereiopod 1 a little more than half as wide as long; lateral margin devoid of spines; dactyl with a few small setae on posterior margin. Sides of pleotelson almost parallel for more than half their length, then converging gradually; posterior end more broadly rounded than in the other species. Length, excluding antennae, 4.5–6.5 mm.

Color (after 14 years in formalin).—Dorsal and ventral surfaces of body, antennae 1 and 2, proximal segments of pereiopods, and uropods covered with black chromatophores.

Types, deposited in the U. S. National Museum.—Holotype, adult male, 5.8 mm in length, no. 96960; allotype, female with oostegites developed, 4.6 mm in length, no. 96961 and 44 paratypes, no. 96962, all from a 1-meter net haul made at Willtown Bluff, Edisto River, S. C., April 1, 1940.

Remarks.—The cuticle of the body and appendages is sculptured as shown in the drawing of the maxilliped. Young specimens, 2.6 mm in length, have 3-segmented maxillipedal palps as in the adult. Pereiopod 3 resembles pereiopod 2 in all details. Pereiopods 4–6 resemble pereiopod 7; pereiopods 5 and 7 are about equally long, somewhat longer than pereiopod 4, but shorter than pereiopod 6. Both lobes of pleopods 1 and 2 and the exopod of pleopod 3 are natatory, bearing plumose setae on their margins; the endopod of pleopod 3 and both lobes of pleopods 4 and 5 are respiratory in function. This division of the pleopods is found throughout the genera *Chiridotea* and *Saduria*. In very young specimens of *C. almyra*, the second antennae are not nearly as much longer than the first antennae as they are in mature specimens. This might lead to confusion with young specimens of *C. coeca*, but the two species can be easily separated by the difference in shape of the pleotelson.

In addition to the type locality I have identified *C. almyra* from Kings Ferry, Ogeechee River, Ga., and from two localities in the Hudson River, N. Y., near Barrytown and Haverstraw, respectively.

The salinity must be very low at all these localities, since they are well upstream from the river mouths, but I unfortunately have no data on the salinity at the sites of collection. In the samples collected at Willtown Bluff and Kings Ferry, a number of species known to be euryhaline and frequently found in brackish water were present. These include the copepod *Eurytemora hirundoides* Nordquist, the amphipod *Corophium lacustre* Vanhoffen, the isopod *Cyathura carinata* (Krøyer), and the polychaete *Scolelepides viridis* (Verrill).[4] In addition, the freshwater copepods *Osphranticum labronectum* Forbes and species of *Diaptomus*, *Cyclops*, and *Macrocyclops* were present. Taken at Haverstraw were such brackish-water forms as the amphipods *Leptocheirus plumulosus* Shoemaker and *Corophium lacustre* Vanhoffen, and the isopod *Cyathura carinata* Krøyer.

Chiridotea almyra is clearly limited to water of low salinity, and perhaps even enters fresh water. The strictly marine species, *C. coeca* and *C. tuftsi*, are scavengers on sandy bottoms, where they burrow just beneath the surface of the sand (Tait, 1927). Presumably *C. almyra* has a similar way of life in its brackish environment.

DISCUSSION

Of the mouthparts of *Chiridotea*, only the maxillipeds have been previously figured. Both Harger and Richardson illustrate the palp as 3-segmented; Collinge shows the palp as 3-segmented in *C. coeca*, 4-segmented in *C. tuftsi*. I have examined maxillipeds from both species and found only 3-segmented palps. It is likely that Collinge's specimen of *C. tuftsi* was anomalous. The fine setae on the outer margins of the palp are shown by Harger, but not by the other authors.

The remaining mouthparts are similar in all three species of *Chiridotea*. The presence of a single seta on the inner lobe of the first maxilla is, as far as I know, unique among idotheid genera.

[3] From the Greek αλμυρός, brackish.

[4] Identified by Marian H. Pettibone.

The absence of a molar on the mandible is also an unusual feature.

Although both *C. coeca* and *C. tuftsi* are reported to have eyes on the dorsal surface of the head, medial to the lateral incisions, I have been unable to find them in either of these species or in *C. almyra*. This is undoubtedly due to the action of the preservative, for eyes were noticed in living specimens by Tait (1927) in his interesting paper on the natural history of *C. coeca* and *C. tuftsi*.

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LETTERS TO THE EDITOR

*The Electrometer at High Frequencies.**

It is not generally appreciated, I think, hat the quadrant (or string) electrometer s a useful instrument at high frequencies, lthough this was suggested as early as 881 by Ayrton and Fitzgerald, and also by otier (see "Electrometer," Encyclopedia ritannica, 11th ed). So far as I am aware ie use of electrometers on a-c has been restricted to power measurements at line frequencies. This application is described in the standard books on electrical measurements (e.g., Laws, Michals, Harris). The high resistance and low capacity of an electrometer suggest an extension of its use to the megacycle range.

We denote the potentials of the two fixed members (plates) by A and B, and that of the needle by N, all with respect to the

*Received May 27, 1955.

case which is at ground. According to the elementary theory (Maxwell) the deflection θ is proportional to the product of the potential difference between the plates and the potential of the needle with respect to the mean potential of the plates, i.e.

$$\theta = K(A-B)[N-(A+B)/2]. \quad (1)$$

In the higher order theory, K depends on θ and on the potentials, but eq. 1 is appropriate to the null methods to be described, for which θ is always zero. Two applications of eq. 1 are given below as examples.

(1) MEASUREMENT OF HIGH-FREQUENCY VOLTAGE

The needle is grounded to the case so that $N = 0$. Suppose A is the unknown potential and B is an adjustable known potential, and that B is adjusted so that $\theta = 0$. Then eq. 1 gives

$$A^2 = B^2. \quad (2)$$

If B is a steady potential $\bar{B}$, and A is an alternating potential $\tilde{A}$, then on account of the slow response of the needle, eq. 2 gives

$$|\tilde{A}|^2 = \bar{B}^2, \quad (3)$$

so that the rms value of A is determined by direct comparison with a known d-c voltage. The sensitivity of an electrometer depends on the applied potentials. I have found that with a Lindemann-Ryerson electrometer the potentials of eq. 3 should exceed about 5 volts to enable the comparison to be made to 1 percent. At 25 volts the sensitivity is about 1 in 5,000 and for somewhat higher voltages the instrument is unstable. The unknown potential thus needs to be amplified or attenuated by a known amount to put $\tilde{A}$ in a favorable range. No difficulty was experienced in using the instrument for voltage measurements at 1 Mc/s and much higher frequencies could doubtless be used.

(2) A SLIDE-BACK "LOCK-IN" AMPLIFIER AND PHASE-METER

Suppose A to be an alternating, and B a steady potential as before, but that N is the sum of a steady and an alternating potential, i.e., $N = \bar{N} + \tilde{N}$. Then eq. 1 is

$$\begin{aligned}\theta/K &= (\tilde{A} - \bar{B})[\tilde{N} + \bar{N} - (\tilde{A} + \bar{B})/2], \\ &= (\tilde{A}^2 - \bar{B}^2)/2 + \tilde{N}\cdot\tilde{A} - \bar{B}\cdot\bar{N} + \\ &\quad \bar{N}\cdot\tilde{A} - \bar{N}\cdot\bar{B}, \quad (4)\end{aligned}$$

in which time averages are understood so that $\bar{N}\cdot\tilde{A}$ and $\bar{B}\cdot\tilde{N} = 0$. The needle is temporarily grounded so that $N = 0$ and either $\tilde{A}$ or $\bar{B}$ is adjusted so that the deflection $\theta = 0$; eq. 3 then applies. The potential N is restored and $\bar{N}$ adjusted so that $\theta = 0$. Eq. 4 becomes

$$\bar{N}\cdot\tilde{A} = \bar{N}\bar{B}, \qquad (|\tilde{A}| = \bar{B}). \quad (5)$$

If $\bar{N}$ and $\tilde{A}$ are of different frequencies, then the time average of $\bar{N}\cdot\tilde{A}$ will be zero and balance will be achieved with $\bar{N} = 0$. Thus the device acts as a "lock-in amplifier" of the square-law type; it is not sensitive to harmonics. If the two frequencies are alike, eq. 5 gives

$$\begin{aligned}|\tilde{N}|\,|\tilde{A}|\cos\phi &= |\bar{N}|\,\bar{B}\cos\phi = \bar{N}\bar{B}, \\ \text{or} \quad \cos\phi &= \bar{N}/|\tilde{N}|, \quad (6)\end{aligned}$$

in which ϕ is the phase between $\tilde{A}$ and $\tilde{N}$. The alternating potential $|\tilde{N}|$ may be measured independently, or, if either of the a-c circuits be supplied with a variable (uncalibrated) phase shifter, ϕ may be adjusted to maximize $\bar{N}$ to the value $|\tilde{N}|$.

Eq. 6 thus shows how a phase ϕ may be determined from d-c measurements only, e.g. from the readings of a potentiometer used to supply $\bar{N}$.

The operation of the Lindemann-Ryerson electrometer as a phase meter was checked at 1 Mc/sec using a calibrated phase shifter as a reference. Twenty values of θ, at equal intervals of 0.1π radian were set by the phase shifter and the corresponding values of $\bar{N}$ and $\tilde{N}$ were measured with commercial voltmeters. A curve of the form

$$y = a\cos(\phi + \alpha) \quad (7)$$

was fitted to the data by least squares. The value of y calculated from eq. 7 differed from the known value by more than 1 per cent only for the two values of ϕ for which $\cos\phi$ was less than 0.1, and at these points the least square values of ϕ were in error by 0.005 radian.

MARTIN GREENSPAN
National Bureau of Standards

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington held its annual business meeting on April 19, 1955, and elected the following officers: President, LAWRENCE KRADER; Vice-President, MARK HANNA WATKINS; Secretary, JOSEPH CASAGRANDE; Treasurer, BETTY J. MEGGERS; Councilors to the Board of Managers, JOHN M. CORBETT (1957), MARCUS GOLDSTEIN (1958), GEORGE TRAGER (1958); Representative to the Washington Academy of Sciences, FRANK M. SETZLER.

A report of the membership and activities of the Society since the last meeting follows: The membership on April 19, 1955, totaled 107, a decrease of 2 from the total reported in January 1954. New members elected during the year totaled 21 and were: THOMAS G. BAKER, NANCY BAYLEY, CALVIN L. BEALE, RUTH E. BROWN, PHILIP H. CLARK, LUCY KRAMER COHEN, YEHUDI A. COHEN, FRANCIS W. FELSMAN, THOMAS GLADWIN, ALICE PARKER HUNT, NORMAN KEY, CHARLOTTE LEVIN, MAY I. B. MAGRATH, MARGARET A. MATUS, HAROLD ORLANS, CARROLL QUIGLEY, BARBARO L. RICHARDSON, MARK E. RICHARDSON II, JOSEPH E. SIMONS, RUDOLF SOBERNHEIM, and ROBERT C. WRENN. Three deaths were reported: C. J. CONNOLLY, DIETHER VON DEN STEINEN, and HENRY P. ERWIN. Five members resigned, and 15 were dropped from the rolls.

The report of the Treasurer for the year ending April 19, 1955, was read and conditionally accepted.

Activities: The panel of integrated papers representing a series of theoretical and interpretative phases on New World prehistory was continued under the program committee consisting of Drs. BETTY J. MEGGERS, MARSHALL T. NEWMAN, and CLIFFORD EVANS (chairman). The following is a list of speakers and their subjects:

February 12, Dr. ALBERT SPAULDING: *The new interpretations of prehistoric cultural development in the eastern United States.*

March 12, Drs. JOHN CORBETT and MARSHALL NEWMAN: *American Indians in the Pacific: An appraisal of Heyerdahl's theories.*

April 23, Dr. BETTY J. MEGGERS: *The coming of age of American archeology.*

At the beginning of the new academic year a new series of symposia concerning the relationship of anthropology to other fields with special emphasis on its contribution to administrative problems and programs were arranged by Drs. THOMAS GLADWIN, JOSEPH CASAGRANDE, and GORDON MACGREGOR. The following is a list of speakers and their topics:

October 22, Dr. JOHN BENNETT: *Anthropology and the study of intercultural experience.*

November 16, Dr. GEORGE DEVEREUX: *Psychiatry and mental health.*

December 16, Dr. BENJAMIN PAUL: *Public health.*

January 18, Drs. WILLIAM KELLY and THOMAS GLADWIN: *Administration of native peoples—Southwestern United States and the Pacific Islands.*

February 15, Dr. LAURISTON SHARP: *Technical assistance programs.*

March 15, Dr. E. ADAMSON HOEBEL: *Anthropology and law.*

April 19, Dr. W. MONTAGUE COBB: *The relationship of physical anthropology to medicine.*

Revised statement of the Treasurer to cover the period of January 1, 1954, through April, 19, 1955, to conform with the changes of the new fiscal year as amended in bylaws, follows:

Receipts:			
Balance forward, Dec. 31, 1953:			
Washington Loan & Trust:			
Checking account	715.93		
Perpetual Building: Savings account	569.00		
		$1,284.93	
Dues collected (1954 and 1955)		230.00	
Sales of old Anthropologists		92.87	
Sales of 75th anniversary volume		96.00	
Sale of Washington Sanitary stock		997.88	
Dividends and interest (cash):			
Investment Co. of America	75.66		
Mass. Investment Trust Co.	114.35		
Perpetual Building & Loan (Savings)	33.45		
Washington Sanitary Housing	10.00		
		233.46	
Total cash receipts			$2,935.14
Expenditures:			
Printing announcements, etc.		$163.04	
AAA dues (Treas., Sect., Life Member for 1954 & 1955)		45.00	
Treasurer's and Secretary's expenses		5.43	
Connolly memorial fund		5.00	
Speaker's expenses (10 meetings)		409.51	
ASW 75th anniversary volume—publishing and manuscript typing costs		996.16	
Cost of distribution of ASW volume—to members and sales		19.46	
Total cash expenditures			1,643.60

Cash balance		$1,291.54
Distributed as follows:		
Wash. Loan & Trust (Riggs Bank)—Checking account	291.21	
Perpetual Building & Loan—Savings Account	1,000.33	
		$1,291.54

Statement of investments as of closing of books April 19, 1955:

Investment Company of America:			
100 shares	# L6754	Issued: January 29, 1951	
10 shares	# L05141	January 29, 1951	
5 shares	# L08905	December 24, 1952	
3 shares	# L013096	December 21, 1953	
118 shares	# LU1619	February 19, 1954	
11 shares	# L019868	December 21, 1954	
247 shares @ $8.34			$2,059.98
Massachusetts Investors' Trust			
50 shares	# M23522	Issued: January 24, 1951	
1 share	# M378627	February 8, 1954	
51 shares	# M378626	February 8, 1954	
1 share	# M378625	February 8, 1954	
1 share	# M436033	February 25, 1954	
1 share	(Returned for reissue due to incorrect name on share—March 8, 1954)		
105 shares @ $28.71			3,014.55
Total investments			$5,074.53

In December 1954 the Board of Managers voted to authorize the expenditure of funds to publish the lectures delivered in the program year of 1953–54 and three additional papers on interpretative archeology in honor of the 75th anniversary of the founding of the Society. One thousand copies were delivered in March 1955, and copies were distributed at the close of the Annual meeting. After members of the Society received their copies, the others were offered for sale for the below-cost price of $1. The 144-page volume, edited by Drs. Clifford Evans and Betty J. Meggers, is entitled "New Interpretations of Aboriginal American Culture History" and contains the following papers:

EISELEY, LOREN C.—*The Paleo-Indians: Their survival and diffusion.*

SPAULDING, ALBERT C.—*Prehistoric cultural development in the Eastern United States.*

WILLEY, GORDON R.—*The interrelated rise of the native cultures of Middle and South America.*

REED, ERIK K.—*Trends in Southwestern Archeology.*

DRUCKER, PHILIP—*Sources of Northwest Coast culture.*

EVANS, CLIFFORD—*New archeological interpretations in northeastern South America.*

EKHOLM, GORDON F.—*The new orientation toward problems of Asiatic-American relationships.*

TRAGER, GEORGE L.—*Linguistics and the reconstruction of culture history.*

MEGGERS, BETTY J.—*The coming of age of American archeology.*

CARL F. MILLER, *Secretary*

WASHINGTON SCIENTIFIC NEWS

ALLEN F. WOODHOUR has received $200 from the Academy as a grant-in-aid for researches on a quantitative acid-fast technique, to be used in connection with research on mycobacterium tuberculosis. He is carrying on this work under Prof. E. R. Kennedy in the Biology Department at Catholic University. The funds are provided by the American Association for the Advancement of Science, on the recommendation of the Academy. Some funds are still available, and the Academy's Committee on Grants-in-Aid for Research is willing to receive additional applications.

The National Bureau of Standards has developed a type of statistical design that makes it possible to reduce greatly the effect of systematic errors in physical-science experiments without increasing the number of measurements. Known as generalized chain blocks,[1] the NBS designs require no more than two measurements for every experimental condition.

Systematic errors are often comparatively large in physical-science experiments, but the random errors in such measurements are usually very small, and so the reduction of systematic errors engages most of the experimenter's attention. Common methods for minimizing systematic errors are careful control of experimental conditions and the use of reference materials for periodic calibration of the measuring equipment. However, through the use of statistical designs it is often possible to eliminate, at least partially, the need for such elaborate precautions. This is done by dividing the measurements into "blocks," that is, groups of measurements that are either subject to the same systematic effects or contain measurable trends. Thus, for example, four sheets of rubber that are cured simultaneously in the same mold constitute a block even if systematic differences exist between the cavities of the mold. So long as these systematic differences are constant from one cure to the next, they can be statistically determined, and appropriate corrections can be applied to the data.

[1] For further details, see *Chain block designs with two-way elimination of heterogeneity*, by John Mandel, Biometrics **10**, 251. 1954.